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Review

Environmental applications of the Coase Theorem

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ABSTRACT

The Coase Theorem has a central place in the theory of environmental economics and regulation. Its applicability for solving real-world externality problems remains debated. We first place this seminal contribution in its historical context. We then survey the experimental literature that has tested the importance of the many, often tacit assumptions in the Coase Theorem. We discuss a selection of applications of the Coase Theorem to actual environmental problems, distinguishing between situations in which the polluter or the pollutee pays. Most substantive examples of Coase-like bargaining involve more than two parties. It is not clear whether the outcomes of these bargains were Pareto optimal rather than merely Pareto improving. While limited in scope, Coasian bargaining over externalities offers a pragmatic solution to problems that are difficult to solve in any other way.

1. Introduction

The Coase Theorem (Coase, 1960) is a central result in economics. It shows how, under certain conditions, economic actors can arrive at an efficient solution to an externality *without direct government involvement*. Prior to Coase, economists thought that externalities, which are at the heart of environmental economics, necessitate government regulation, particularly taxation (Pigou, 1920). The Coase result has been used to argue that environmental externalities do not require government regulation beyond the establishment and enforcement of property rights. Skepticism remains, however, regarding the applicability of Coase's theoretical result to real-world environmental problems.

Coase's aimed to "expos[e] the weaknesses of Pigou's analysis" (Coase, 1991). We study to what degree he has, not in theory but in practice.¹ Specifically, we evaluate the extent to which the Coase Theorem has been or could be used to solve actual environmental problems,

drawing on experimental evidence and real-world examples.

Major textbooks in environmental economics discuss the Coase Theorem. Two central tenets are always there: (1) a Pareto optimal outcome can be obtained through bargaining if initial property rights are clearly assigned, and (2) that outcome is independent of who initially holds those rights. The textbooks diverge, however, in their assessment of the applicability of the Coase Theorem to actual environmental problems.² Indeed, Cherry et al. (2013) argue that "a consensus has not been reached over the validity and importance of the Coase Theorem and how it can be effectively applied to [environmental] policy." Six textbooks present the Coase Theorem as an intellectual curiosity with little value in real life (Anderson, 2019; Hodge, 1995; Pearce and Turner, 1990; Perman et al., 2011; Tietenberg and Lewis, 2018; Turner et al., 1994).³ Harris and Roach (2018) additionally argue that seemingly voluntary transactions may in fact be coercive and thus unjust. In contrast, eight other textbooks emphasize that the Coase

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¹ Medema (2020) and Lai (2010) survey how the Coase Theorem came about, the initial response by the economics profession, and its eventual impact. They do not focus on practical applications in environmental policy.

² Laurent (2020) equates the Coase Theorem to tradable emission permits.

³ Endres and Radke (2012) and Lewis and Tietenberg (2019) mention the Coase Theorem only in passing.

Theorem can be used in certain circumstances, while also highlighting its restrictive assumptions and limited applicability (Baumol and Oates, 1988; Field and Field, 2009; Goodstein, 2005; Keohane and Olmstead, 2016; Kolstad, 2011; Phaneuf and Requate, 2017; Wills, 1997; Kahn, 2020). Three textbooks go further, presenting the allocation of property rights followed by bargaining as a viable policy option (Berck and Helfand, 2011; Hanley et al., 2007, 2013). Environmental economists thus appear to be divided about the practical relevance of the Coase Theorem under conditions that characterize many environmental problems, including information constraints and transaction costs.

We are the first to review evidence for the Coase Theorem applied to actual environmental problems, although there are papers that describe applications of the Coase Theorem to a single case (Hanley and Summer, 1995; Ruml, 2005; Pirard, 2012; Folefack, 2014; Byun, 2015). We qualitatively discuss a number of cases. Applications of the Coase Theorem are hard to find, potentially because no direct government involvement is required. Documentation may therefore be missing, unless the case is newsworthy or amusing – such a noisy chemical plant offering chocolates to nearby residents⁴ or the obese man paying the man sitting next to him on a plane \$150 for being allowed to take up some of the latter's seat.⁵ Personal anecdotes in which bargaining is used to address externalities abound: A colleague's father offered to buy a rug for his upstairs neighbor to muffle the sound of the neighbor's grandchild dribbling a basketball. A colleague offered brownies and money, and an author offered pears to their respective neighbors if they would quit calling the cops on their practising college bands for noise violations. Bargains like these are not systematically recorded; we cannot know whether these are exceptions or the rule. They are also less relevant to the question of whether Coasian bargaining can substitute for Pigovian regulation for more substantial externalities.

One challenge with surveying applications of the Coase Theorem is that there is non-trivial disagreement as to what constitutes Coasian bargaining. What if, for example, one of the bargaining parties is a local or a national government? Should compensation that takes place *after* the damage has occurred be counted? Strictly speaking, the Coase Theorem applies to bargains between two agents, but its proponents have suggested bargaining as a solution to problems involving larger numbers of actors. Resolving such disagreements is beyond the scope of this article. Therefore, we err on the side of being inclusive and leave it to the reader to decide whether a particular example meets her preferred definition of Coasian bargaining.

A consistent theme that emerges is that many cases where bargaining looks feasible *ex ante* end up in court nonetheless. Cases that settle could be viewed as Coasian bargaining with some transaction costs where the involvement of the legal system helps render the contract between parties enforceable. However, a failure to come to a resolution before a (costly) trial is more consistent with imperfectly specified property rights. Indeed, our review of prominent court cases suggests that disagreement over whether the polluter has the right to inflict the harm in question – in other words, disagreement over the nature of the relevant property rights – is a major reason why more Coasian bargains are not being struck and instead the relevant parties end up in court. In other situations, there appears to be substantial uncertainty over whether or not a property right will be enforced by the courts. Both the definition of property rights and the enforcement of contracts – including any Coasian bargains negotiated between parties – point to the critical role of public institutions: even if the government itself does not act as a Pigovian regulator, it still plays a central role in creating and maintaining the conditions that enable successful Coasian bargaining.

Strictly speaking, the Coase Theorem is beyond empirical analysis. We observe neither the Pareto optimum nor the counterfactual in which the other party holds the property rights. We therefore necessarily

restrict our attention to the observation of people and organizations negotiating over externalities. By the revealed preference argument, if Coasian bargaining is successful, it must have produced a Pareto improvement. How close or far this improvement is from the optimum is not observable.

Some recent literature on the Coase Theorem distinguishes between “entitlements” and “property rights”, where “entitlements” refers to the initial allocation and “property rights” materialize only after negotiations have taken place (e.g. Slaev, 2017; Slaev and Daskalova, 2020). While such a distinction is important in some cases, in this paper we use the term “property rights” to refer to the initial delineation of the parties' rights, as this is the more common usage in economics.

The paper proceeds as follows. Section 2 discusses the Coase Theorem, its key assumptions, and influential interpretations. Section 3 reviews experimental tests of the Coase Theorem. Section 4 briefly reviews how the US legal system might hamper the ability to implement Coasian bargains. Section 5 assesses natural evidence, distinguishing between cases where the polluter pays and where the pollutee pays. Section 6 charts further research and concludes.

2. The Coase Theorem

2.1. Coase in context

The Coase Theorem was published in the *Journal of Law and Economics*. Originally, it is not a theorem that Coase formalized let alone proved. There is not a single equation or rigorous definition in the paper.⁶ Instead, Coase offers a detailed discussion of common law on liability and nuisance, disagreeing with Pigou's solution to the problem posed by externalities.

The solution proposed by Pigou (1920, II.XL11) is a program of taxes or subsidies:

“for every industry in which the value of the marginal social net product is greater than that of the marginal private net product, there will be certain rates of bounty, the granting of which by the State would modify output in such a way as to make the value of the marginal social net product there more nearly equal to the value of the marginal social net product of resources in general, thus [...] increasing the size of the national dividend and the sum of economic welfare; and there will be one rate of bounty, the granting of which would have the optimum effect in this respect. In like manner, for every industry in which the value of the marginal social net product is less than that of the marginal private net product, there will be certain rates of tax, the imposition of which by the State would increase the size of the national dividend and increase economic welfare; and one rate of tax, which would have the optimum effect in this respect.”

Pigou argues for the State to intervene to internalize externalities, by imposing taxes on negative ones and subsidies (“bounties”) on positive ones.

Coase's critique of the Pigovian framing of environmental problems focuses on the nature of the transfer payment required to internalize an externality. He argues that, because of the symmetry of the problem, a tax on producers of a negative externality is not the only possible solution:

“The traditional approach has tended to obscure the nature of the choice that has to be made. The question is commonly thought of as one in which A inflicts harm on B and what has to be decided is: how should we restrain A? But this is wrong. We are dealing with a problem of a reciprocal nature. To avoid the harm to B would inflict

⁴ Schmidt, De Limburger, 20 Dec 2019.

⁵ Hosie, Insider, 4 Mar 2019.

⁶ Stigler (1966) coined the term “Coase Theorem” but did not restate Coase' insight as a theorem.

harm on A. The real question that has to be decided is: should A be allowed to harm B or should B be allowed to harm A?"

Coase takes issue with Pigou's premise that the one who causes the externality should be the one who is rewarded (if the externality is positive) or penalized (if the externality is negative). A review of the textbooks cited above suggests that Coase's criticism of Pigou's asymmetric treatment of pollutee and polluter is less well-known. Coase discusses the different treatment under common law of escaped domesticated and wild animals. If a domesticated animal escapes and does damage, its owner is liable. If a wild animal escapes from captivity and does damage, the victim is liable. Coase underlines the arbitrary nature of this distinction by discussing the rabbit, which is not a *domesticated* but a *wild* animal under common law.

Coase' central example is cattle eating a neighbor's crops. He argues that, if the cattle-owner is liable for the damage done by her steers, she would limit the size of her herd to the point where the damage done by one additional steer equals the cattle's incremental profit. Coase then argues that, without such liability, the farmer would be willing to pay his neighbor to reduce the herd size, and that he would pay up to the point where the damage avoided by one fewer steer equals the marginal steer's value to the cattle-raiser. In other words, the final outcome is the same regardless of whether or not the cattle-owner has a duty to compensate for harm to her neighbor.

This example leads to the Coase Theorem: In the presence of externalities and clearly defined property rights, agents can bargain their way to a Pareto optimum, and that Pareto optimum is the same regardless of who imposes an externality on whom.

Coase underlines that his conclusion only holds if there are no costs involved in the transaction, and that it is easier to reach agreement if fewer parties are involved. He implicitly assumes that people are well-informed, act in their self-interest, that the money changing hands does not affect the demand or supply curves, and that the agreement reached by the bargaining parties will be enforced by courts if necessary. Another assumption is that the willingness to pay to avoid harm is equal to the willingness to accept compensation for harm. Coase himself did not seem to believe that these conditions would hold in most situations, emphasizing the importance of considering the net value of alternative (imperfect) institutions that can be implemented in the presence of transaction costs. He later said that "the legal system will have a profound effect on the working of the economic system and may in certain respects be said to control it" (Coase, 1991).

In his seminal paper showing that competitive equilibrium with a Pigou tax is a Pareto optimum, Baumol (1972) attacks Coase, writing

"It is ironic that just at the moment when the Pigovian tradition has some hope of acceptance in application it should find itself under a cloud in the theoretical literature. [...] Ronald Coase has asserted that the tradition has not selected the correct taxation principle for the elimination of externalities, and may not even have chosen the right individuals to tax or to subsidize."

Baumol's words may partly explain the divergent opinions of environmental economists on the Coase Theorem. However, Baumol does not address Coase' core contentions: the initial allocation of property rights and the effect of transaction costs. Baumol is interested "in the large numbers case", where bargaining is impractical – whereas Coase is interested in externalities between a few agents. Correcting Buchanan and Craig Stubblebine (1962), Baumol shows that compensation of victims is not optimal *at the margin* but adds, on page 312, "except, of course, for lump sum payments." Baumol's objections are therefore not of a technical nature, but rather pragmatic: Coase confused policy makers who were just beginning to accept Pigovian taxes.

Coase argued that "[t]he significance to me of the Coase Theorem is that it undermines the Pigovian system", but he continues: "[s]ince standard economic theory assumes transaction costs to be zero, the Coase Theorem demonstrates that the Pigovian solutions are

unnecessary in these circumstances. Of course, it does not imply, when transaction costs are positive, that government actions (such as government operation, regulation or taxation, including subsidies) could not produce a better result than relying on negotiations between individuals in the market. Whether this would be so could be discovered not by studying imaginary governments but what real governments actually do. My conclusion; let us study the world of positive transaction costs." (Coase, 1991). Coase underlines the importance of transaction costs in the applicability of his theorem.

2.2. Coase formalized

Mas-Colell et al. (1995), among others, state the Coase Theorem formally. Their proof is reproduced in the Appendix. It reveals key underlying assumptions:

1. **No wealth effect** Quasi-linearity in the numeraire makes the externality independent of budgets and side-payment.
2. **Perfect information** The agents know each other's indirect utility functions.
3. **Rationality** Agents maximize utility.
4. **No endowment effect** The utility functions are smooth in the status quo, and economic agents behave the same whether or not they have the right to be free of externalities.
5. **Zero transaction costs** The bargain can be struck without incurring costs.

Medema (2020) splits the Coase Theorem into three parts. The *efficiency thesis* states that, once property rights are assigned, a Pareto optimum is achieved. As the assignment of property rights completes the market, this result is equivalent to the First Fundamental Theorem of Welfare Economics. The *invariance thesis* states that the Pareto optimum is independent of the initial allocation, a result that is sharper than the Second Fundamental Theorem of Welfare Economics. *Zero transaction costs* is the third part. Large parts of economic theory assume that transaction costs are negligible. If so, the Coase theorem illustrates that there is no need for direct government intervention to internalize externalities.

2.3. Coase generalized

Ellingsen and Paltseva (2016) offer a more general proof of the Coase Theorem. They show that the Coase Theorem only holds for two economic agents – one polluter and one pollutee, a 1×1 bargain. If there is more than one person involved on either side – $m \times 1$, $1 \times n$ or $m \times n$ bargains – then coordination problems between polluters or pollutees may prevent the attainment of an efficient solution.

As a corollary, if there is no coordination problem, the Coase Theorem does hold for more than two agents. For instance, a $1 \times n$ bargain between 1 polluter and n pollutees is equivalent to $n1 \times 1$ bargains if there is no fixed cost of emission reduction, the variable costs are linear in emission reduction, the environmental damage is linear in emissions, and the polluter cannot exert market power over the pollutees. Under these (stringent and unrealistic) assumptions, each pollutee would strike a separate bargain with the polluter and those bargains would be efficient as the pollutees do not affect each other.

In more realistic settings, the action of one pollutee does affect the other pollutees – or polluters may affect each other. This would be the case if, for instance, the impact of pollution is non-linear in emissions. Then, coordination problems arise, and a pollutee may choose to free-ride on the efforts of her fellow pollutees to bargain with the polluter.

Coordination problems have been thoroughly studied and are hard to solve.⁷ In the context of common pool resource management (oil

⁷ Ellingsen and Paltseva (2016) review the literature.

exploitation), for example, Libecap and Wiggins (1984) show that 4–5 companies could negotiate an agreement and that 10–12 companies could only agree to request state intervention. Wiggins and Libecap (1985) add that asymmetric information hampers private contracting for oil exploitation in a common pool. Libecap and Wiggins (1984) also find that, if there are more than 12 parties, no agreement at all could be reached. Libecap and Wiggins (1985) argue that this is because oil companies are sufficiently influential to block state intervention.

However, Ellingsen and Paltseva (2016) show that, while $m \times n$ bargains do not attain efficiency, they do improve welfare. In the examples discussed below, we focus on coordination and improvements in welfare resulting from bargains between two or more actors, rather than on Pareto optimality. These can be thought of as impure forms of the Coase Theorem, or examples of Coase-like bargaining that do not necessarily result in a Pareto optimum.

3. Coase in the lab

Many laboratory experiments have been designed to understand which assumptions underlying the Coase Theorem are crucial and which are mathematically convenient but can be relaxed without overturning its practical implications. We briefly summarize the findings, focusing the conditions that are important for achieving Pareto optimal outcomes.

Hoffman and Spitzer (1982) are generally credited to be the first to explicitly test, and confirm, the Coase Theorem in the lab.⁸ Subjects were assigned to groups of two or three. One or two subjects were randomly assigned to be “controllers”, who, analogously to being assigned initial property rights in the Coase Theorem, had the right to unilaterally choose the set of payoffs players would receive. The other participant(s) could attempt to influence the outcome via negotiations, including by offering to transfer some or all of her earnings to the controller. Whether or not payments were known to all participants varied. Contracts were enforced by the experimenter. If payoffs were known and there was only one controller, 89.5% of the 114 experimental decisions resulted in Pareto optimal outcomes. In experiments with limited information and joint controllers, success rates were substantially lower. In the original set-up, however, it was impossible to distinguish between a fair allocation and a Pareto optimal one. Harrison and McKee (1985) refine Hoffman and Spitzer’s experimental design to make cooperation individually rational. They find strong support for the Coase Theorem: The Pareto optimum is found in 97% of experiments.

Since then, many experimental studies of the Coase Theorem and its limitations have been conducted, yielding much insight about when property rights are sufficient to yield Pareto optimal outcomes. We found four review articles. Bohm (2003) reviews seven experimental papers published between 1982 and 1998. When there are zero transaction costs, complete information, and small incentives, subjects tend to opt for a fair allocation rather than a Pareto optimal one. Higher incentives lead to a shift to the Pareto optimum. The Pareto optimum becomes unattainable if transaction costs increase.

Camerer and Talley (2007) review these and later experiments. They report that private (rather than public) information does not affect the ability of participants to attain the Pareto optimum. Asymmetric information does: Participants are less willing to trade in this case. Less secure property rights attenuate the effect of asymmetric information. Camerer and Talley (2007) also speculate that endowment effects would hamper Coasian bargaining.

Crosron (2009) reviews largely the same literature but with a

⁸ Prudencio (1982) finds that a contract negotiated over an externality comes, on average, within 3% of the Pareto optimum, and that there is no statistically significant difference between cases where the polluter or pollutee holds the initial property rights. Prudencio’s experiment ends with an ultimatum, and his players appear to be motivated by fairness as well as efficiency.

different focus: She emphasizes that the Coase Theorem holds also when stress-tested with larger numbers of participants, asymmetric payoffs, uncertain payoffs, and more complicated bargaining. Finally, Prante et al. (2007) conduct a meta-analysis of experimental results, with the probability of obtaining the Pareto optimum as the dependent variable. They find that transaction costs and time-limits have a negative effect on that probability, while face-to-face bargaining and information have a positive effect.

These four survey papers establish that, at least in the lab, the Coase Theorem holds under its original assumptions – and that it sometimes holds under conditions that are less strict. One paper was published since. Bar-Gill and Engel (2016) find that the Coase Theorem also holds if either party can block the transaction and have the experimenter take away the good that they are bargaining over with minimal compensation. As above, a deviation from the strict assumptions of the Coase Theorem does not necessarily mean that its basic implications collapse.

4. Coase and the US courts

Well-defined property rights (and, implicitly, enforceable contracts) are the key assumption underlying Coasian bargaining. In the US legal system with its strong protection of private property, clearly defining property rights may seem straightforward. However, specifying complete property rights requires attention to such details as mineral rights, wildlife harvesting rights, rights to make noise or emit noxious smells, and so on. As court cases demonstrate, there are many situations in which property rights are sufficiently vague to result in substantial disagreements between the affected parties about who holds a particular right.

There are at least four reasons for the continued existence of ambiguous property rights. First, the common law theory of nuisance makes it very difficult to fully and clearly assign the right either to create or to be protected from an externality, particularly for new types of harms where precedent has not been established. Second, it is difficult to define terms used in legislation and regulation in a way that leaves no room for an alternative interpretation. Third, the existence of multiple levels of government and of multiple, related, laws sometimes creates ambiguity about which law applies to a particular situation. Fourth, new laws and regulations change property rights, and shifting social norms and legal principles change what is deemed permissible.

The common law principle of nuisance is the basic legal principle determining the allocation of property rights around externalities from private property – who has the right to pollute and who has the right to be protected from pollution? The tort of nuisance goes back to the 13th century, in a case where King John of England ruled in favour of Simon of Merston after Jordan the Miller had flooded Simon’s land in an attempt to expand the pond that powered Jordan’s mill (Brenner, 1974). Since the resolution of the Trail Smelter dispute, in which the smoke of a lead and zinc smelter in British Columbia affected farmers in Washington, the legal obligation to be a good neighbour also applies across country borders (Kuhn, 1938).

In modern legal theory, the nuisance principle allows for the “quiet enjoyment” of private property, while protecting other people from “unreasonable interference” as a result of that enjoyment. However, these are vague and general principles. In many situations, what constitutes “unreasonable interference” is unclear, or at least contested, resulting in both polluters and pollutees asserting that they hold the right to inflict the nuisance or to be free from it, respectively (Farber, 2019). These cases sometimes lead to costly nuisance lawsuits, requiring a judge to weigh in to resolve the ambiguous allocation of rights.

Similar issues surface in other environmental settings. There have been lawsuits over the exact definitions of “discharge” (S. D. Warren Co. v. Maine Board of Environmental Protection, 547 U.S. 370 (2006)), “fill material” (Coeur Alaska, Inc. v. Southeast Alaska Conservation Council, 557 U.S. 261 (2009)), “navigable waterway” (Rapanos v. United States, 547 U.S. 715 (2006)), “flood or flood waters” (Central Green Co. v.

United States, 531 U.S. 425 (2001)), and “acceptable noise.”⁹

In other cases, ambiguity over which laws apply prompted costly lawsuits. In one case, the question at hand was whether the state or the Environmental Protection Agency determined what constitutes the “best available control technology” (Alaska Dept. of Environmental Conservation v. EPA, 540 U.S. 461 (2004)). The US Supreme Court has also ruled on whether a federal law governing pesticide law preempted farmers from suing under state law (Bates v. Dow Agrosciences LLC, 544 U.S. 431 (2005)). In another case, the US Supreme Court was asked to rule on whether the Endangered Species Act imposed additional requirements on activities governed by the Clean Water Act (National Assn. of Home Builders v. Defenders of Wildlife, 551 U.S. 644 (2007)).

The considerations above result in imperfectly defined property rights and therefore inhibit Coasian bargaining, at least before precedent has been established through the courts. Determining whether these barriers can be resolved is beyond the scope of this paper.

Furthermore, property rights are not immutable. Rewilding is one example. Large grazers were introduced in many nature reserves in Western Europe to keep landscapes open. Large predators are now being introduced to prevent overgrazing. As these wolves also kill the occasional sheep, the European Union now recommends full compensation for lost livestock.¹⁰ Rhineland-Palatinate guarantees compensation.¹¹ A customary privilege of safety for farm animals has been replaced by an explicit right to compensation.

Environmental standards are generally tightened over time. This implies that rights to pollute tend to disappear and rights to be free of pollution tend to appear. When governments tighten environmental regulations, compensation may be offered to the companies newly deemed to be polluters. Recent examples include more stringent standards for nitrate emissions,¹² odour from farms,¹³ and pesticide bans,¹⁴ with politicians promising to make farmers whole. This is not Coasian bargaining – which is bargaining *given* initial property rights – but rather bargaining over *the assignment* of initial property rights – meta-Coase bargaining, if you will. There is little economic analysis of bargaining over the assignment of initial property rights (Colby, 1995).

Social norms also play a role in the terms on which externalities are bargained over. Protests against and boycotts of large polluters have a long history (Delacote, 2009; Olzak and Soule, 2009). Like property rights, social norms can shift over time with evolving standards of what constitutes a permissible nuisance as opposed to unacceptable behavior. Examples include public littering or the disposal of dog waste. Decades ago, individuals had the “right” to dispose of waste in public spaces, creating disamenities for others. But changing attitudes, sometimes driven by deliberate messaging campaigns and often codified in local laws and ordinances, shifted so that people now generally internalize at least some of the costs of responsible waste disposal while in public areas. As another example, the *Stop the Child Murder* movement in the Netherlands ensured that road safety standards were enforced (Reid, 2017). Similarly, China’s Center for Legal Assistance to Pollution Victims focuses on the enforcement of existing environmental legislation (Xu and Wang, 2006). Lawsuits against emitters of carbon dioxide seek to establish a legal right to an unchanging climate (Tol and Verheyen, 2004; Peel and Osofsky, 2018).

⁹ In the countryside, you should not complain about chickens clucking. Anon, Legal Tribune Online, 10 Dec 2019.

¹⁰ CEC DG Agriculture and Rural Development, 8 Nov 2018.

¹¹ MfULEWF, 2015, Managementplan für den Umgang mit Wölfen in Rheinland-Pfalz.

¹² Anon, Rheinische Post Online, 28 Dec 2019.

¹³ de Vries, Volkskrant, 8 Jul 2018.

¹⁴ Häne, Tagesanzeiger, 12 Dec 2019.

5. Coase in the wild

Strictly, the Coase Theorem applies to a bargain between two players who have no other interactions and do not expect to meet again. Such conditions can be approximated in the lab, but are rarely met in reality. Furthermore, there are few interesting environmental problems with only two agents. However, the experimental evidence shows that the strict requirements of the Coase Theorem can be relaxed without jeopardizing its applicability. We therefore also include examples that involve more than two agents.

In the Coase Theorem, the Pareto optimum will be reached regardless of how property rights are initially endowed. The endowment of initial property rights, however, is critical to the parties involved in that it determines who imposes the externality on whom, and therefore the direction of the transfers involved in the Coasian bargain. Polluter and pollutee are treated differently in law. We therefore separately discuss the cases of the polluter and the pollutee paying.

5.1. Polluter pays

Even if courts are not involved, the prospect of legal recourse to enforce property rights frequently lurks in the background. For example, in 2002, American Electric Power bought all 90 houses in Cheshire, Ohio, and all 221 residents left after health concerns were raised about the release of fly ash from the nearby coal-fired Gavin Power Plant (Kolstad, 2011, p. 262). Homeowners were compensated well above the market value. No lawsuit was filed, but the lawyers negotiating on behalf of the town did threaten to do so.¹⁵

The American Electric Power company was certainly not the first to take this approach. Dow Chemicals, Georgia Gulf, Exxon, Shell, and Conoco have all bought properties near their chemical plants and refineries. Exxon and Shell appear to have started such purchases after explosions at their facilities caused damage to the people living nearby. Georgia Gulf’s program began after a 1987 lawsuit, settled out of court, over contamination and health complaints. Reveilletown, Louisiana, no longer exists after Georgia Gulf bought it. Conoco’s program is also in response to a lawsuit.¹⁶ Dow Chemicals’ program was in response to *the threat of a lawsuit* after chemicals spilled into the drinking water of Morrisonville, Louisiana. The town was abandoned in 1993. These are all examples of the polluter agreeing to pay the pollutee, under the threat that property rights established under the nuisance doctrine would be enforced in court.

These are cases with one polluter and many pollutees. The coordination problem was solved by the polluter. The outcome need not be efficient, because the polluter had monopsony power.

Severonickel, a copper-nickel smelter on the Kola Peninsula in Russia, pays the nearby Lapland Biosphere Reserve \$300,000 annually, following a settlement in a court case Severonickel was likely to lose (Shestakov and Barcan, 2000). Schiphol Airport in the Netherlands is planning to buy out homeowners troubled by the noise from an increase in the number of flights. The airport cannot grow without permission from the municipality of Aalsmeer, the local electorate is concerned about noise, and local politicians worry about re-election.¹⁷ Similarly, the Government of Berlin financially compensates homeowners for the noise it permitted Tegel Airport to make.¹⁸ The Royal Norwegian Air Force has bought houses near its Ørland base and paid for noise insulation for houses further afield.¹⁹ The US Air Force, by contrast, had to be ordered by the courts to pay compensation to the people living near

¹⁵ Seely, New York Times, 13 May 2002.

¹⁶ Schneider New York Times, 28 Nov 1990.

¹⁷ Anon, Noord-Holland Nieuws, 18 Sep 2018.

¹⁸ Bath, Berliner Morgenpost, 17 Dec 2019.

¹⁹ Ellingsen et al., Norsk rikskringkasting, 19 Apr 2016.

the Yokota air base in the outskirts of Tokyo.²⁰

Chlorides in the Rhine river are another example of Coase-without-courts (Bernauer, 1995; Phaneuf and Requate, 2017). *Mines de Potasse d'Alsace* (MdPA) has dumped chlorides, a waste product of its potassium mining, in the Rhine, damaging farming and drinking water production downstream. In the early 1970s, MdPA was the largest point source of chlorides, contributing 30–40% of the load. Companies in Germany and Switzerland also dumped chlorides in the Rhine. In 1972, an agreement was reached between the governments of France, the owner of MdPA, the Netherlands, Germany and Switzerland to jointly compensate MdPA for the profits lost to emission reduction. France, the polluter, covered 30% of the costs and the Netherlands, the pollutee, 34%. Germany and Switzerland covered the remainder. These countries would rather pay MdPA to clean up its act than compel companies in their own countries to do the same. The agreement was revised in 1991. Switzerland now contributes less (3% instead of 6%) because a soda factory, its main source of chlorides, had closed. A quarter of the available funds was diverted from reducing pollution in France to now economical water purification in the Netherlands. While the 1972 agreement mixed payments by polluters and pollutee, after 1991 the polluters paid almost all (91%) of the costs of emission reduction. Transaction costs were high – at one point, the Netherlands recalled its ambassador to France – but not so high that it stopped negotiations.

The US Clean Water Act of 1972 empowered the Army Corps of Engineers to block development if that would damage wetlands. With the property rights firmly established, barter emerged (Field and Field, 2009, p. 206). However, the Army Corps of Engineers cannot take money from developers. Instead, between 1993 and 2000, the Corps granted permits to damage some 24,000 acres of wetlands. In return, developers spent over \$1 billion to create, restore, improve, or protect about 42,000 acres of wetlands (Bayon, 2004). (Berck and Helfand, 2011, pp. 255–6) document that similar barter is common under the US Endangered Species Act, where the Fish and Wildlife Service allows for habitat swaps via mitigation banking.

5.2. Pollutee pays

In 2016, apartment owners in a loft building in New York got together and paid \$11 million for the air rights next door, so that a developer could not build a building that would spoil their view; contributions were larger for owners of apartments on higher floors.²¹ Similarly, Mark Zuckerberg has bought out neighbors in Palo Alto, at a cost of \$43.8 million, to protect both his privacy and security.²²

Vittel, now part of Nestlé, sells mineral water. Run-off from farms near its spring meant that there was too much nitrate in the water. This risked Vittel's brand and its legal designation as "mineral". As farm run-off was below the legal limit and land-zoning prevented the conversion of agricultural land to other purposes, Vittel bought out some farms and negotiated individual long-term contracts with 26 farmers; some farmers did not contract. Vittel made an upfront payment to the farmers, pays them an annual fee, and subsidizes labor and technical advice; contracted farmers can graze their animals on Vittel lands. In return, the farmers minimize the application of nitrogenous fertilizers (Perrot-Maitre, 2006; Phaneuf and Requate, 2017). Nestlé has used a similar approach to protect its other brands.²³ Transaction costs are small relative to the value of branded water, and fell as Nestlé gained experience in bargaining. This is an example in which a single pollutee pays multiple polluters. The coordination problem between polluters was solved by the pollutee, not necessarily efficiently as the pollutee may have exercised monopoly power. An effort to unionize the farmers

failed, because some farmers preferred acting independently. The bargaining power of farmers fell as other farmers contracted (Depres et al., 2008).

Other cases where the pollutee pays the polluter to reduce the harmful activity typically involve governments or non-governmental organizations making the payments. However, the government payments are lump-sum rather than Pigovian per-unit payments.

New York City followed an approach similar to Vittel's to protect the watershed supplying the City's drinking water (Harris and Roach, 2018, p. 60). By 2010, its Watershed Land Acquisition Program had purchased or obtained conservation easements on 100,000 acres (10%) in the Catskill-Delaware watershed from which New York City draws 90% of its drinking water.²⁴ The program continues.²⁵ The problem had arisen because Delaware County could meet new federal standards on drinking water and New York City could not. Purchasing land and changing its management to preserve drinking water quality, while expensive, was cheaper than building new water treatment plants (Church, 2009).

Japan's Green Aid Plan is another example of the pollutee paying to reduce emissions. Japan invested over \$500 million in energy efficiency and clean coal projects in seven other countries in Asia (Evans, 1999). Concerned about winds blowing sulphur from China to Japan, the Cleaner Coal Program stimulates desulphurization technologies for coal-fired power plants.²⁶ The program covers training, technical assistance, and equipment. Desulphurization techniques were not taken up by power plants outside the program (Ohshita and Ortolano, 2002), suggesting it was Japanese funding rather than Chinese concerns about air pollution that caused the installation of scrubbers.

The Baltic Sea Action Plan is similar (Backer et al., 2010). Funded by Sweden (€9 million) and Finland (€2 million), the program provides financial and technical support, particularly to reduce the discharge of nutrients into the Baltic Sea by Estonia, Russia, and several other countries.²⁷ Earlier, Sweden funded similar projects, not just for water but also for air pollution (Löfstedt, 1995; Hassler, 2002).

Not all attempts to pay for pollution reduction are successful. A decade-long attempt by Finland, supported by Norway and Sweden, to clean up sulphur emissions from iron mining and smelting in Karelia and nickel smelters on the Kola Peninsula, came to nothing (Kotov et al., 1996), partly because of the chaotic situation in post-Soviet Russia (Darst, 2001) and partly because of the difficulty in writing and enforcing contracts in Russia (Victor and Skolnikoff, 1999). This example goes to the heart of Coase Theorem: Well-defined property rights and the enforcement of any resulting agreements are key to success.

It is often argued that the Coase Theorem only works with a small number of players. Multiple pollutees would free-ride on buying out the polluter. The City Council of Santa Maria, California, circumvented this problem by imposing a tax on residents near a feedlot causing pungent smells, and using the revenue to pay the owner to cease operations (Kolstad, 2011, p. 259). The coordination problem between pollutees was solved by the local government.

The Nature Conservancy and Environmental Defense Fund, both non-governmental organizations, acted on behalf of many people worried about destructive bottom trawling for fish and shellfish and bought up fishing permits and harmful fishing equipment (Kolstad, 2011, p. 265).²⁸ An NGO in the Netherlands has since 1905 been using donations to buy land to turn it into nature reserves; it now maintains almost 2.5% of the country's area.²⁹ The Nature Conservancy used a

²⁴ Extended NYC LAP.

²⁵ About the watershed.

²⁶ Note that Japan also funds environmental projects that do not directly benefit Japan (Potter, 1994).

²⁷ Baltic Sea Action Plan.

²⁸ Christensen, New York Times, 8 Aug 2006.

²⁹ Natuurmonumenten, Annual Report 2018.

²⁰ Anon, Japan Times, 11 Oct 2017.

²¹ Goodstein, New York Times, 12 July 2019.

²² King, CNN, 25 May 2016.

²³ Agrivair.

reverse auction to pay 33 rice farmers in California's Central Valley to flood 10,000 acres during February and March, a time crucial for migrating birds (Hallstein and Miller, 2014). In all of these cases, there are multiple polluters and multiple pollutees. An NGO put itself in between, a visible hand coordinating the Coase-like bargain. This is not likely to be efficient – the NGO has both monopoly and monopsony power and may well have motives other than the efficient coordination of bargaining. Nonetheless, all parties engaged voluntarily so the transactions are Pareto improving.

6. Discussion and conclusion

The Coase Theorem comes in three parts. (i) The *efficiency thesis* extends the First Fundamental Welfare Theorem to cases where there are externalities: If property rights on an externality are clearly assigned, bargaining leads to a Pareto optimum. (ii) The *invariance thesis* sharpens the Second Fundamental Welfare Theorem. Regardless of whom these property rights are assigned to, the *same* Pareto optimum is reached through bargaining. (iii) The first two parts hold only for zero transaction costs and a number of other restrictive assumptions.

The practical implications of the Coase Theorem are unclear. On the one hand, the Coase Theorem can be used to argue against Pigovian taxes – the government should assign property rights but not otherwise intervene. On the other hand, the Coase Theorem can also be used to argue for Pigovian taxes because transaction costs are positive. We see Coasian bargaining and Pigovian taxation as complements, not substitutes. If there are many polluters and pollutees, Coasian bargaining is impractical; Pigovian taxes are not. However, Pigovian taxes can be impractical too, as when managing an idiosyncratic externality between neighbours. Pigovian taxes are impossible if there is no higher state authority able to impose taxes, as in the case of an externality between two neighbouring countries.

The Coase Theorem means different things to different people. The Coase Theorem states that an externality can be bargained away. Coase presented this as a viable alternative to Pigou taxes for a small number of actors. Coase originally emphasized the arbitrary nature of the initial allocation, but later argued that the Coase Theorem is a *reductio ad absurdum* to show that transaction costs are key.

Textbooks in environmental economics reflect this ambiguity. Some authors present the Coase Theorem as a theoretical curiosity, others as a viable alternative to Pigou taxes. Most take a middle position, emphasizing the many, strict conditions under which the Coase Theorem holds.

Laboratory experiments show that these conditions are not nearly as strict in practice as they are in theory. The Pareto optimum is likely to be found if payoffs are uncertain or asymmetric, bargaining complicated or involving multiple people, and information private – but not if information is asymmetric or transaction costs large.

We document a number of real-world examples of applications of the Coase Theorem. Cases in which the polluter pays are hard to interpret. With one exception, the polluter appears to be paying to avoid a court order – reflecting the nuisance doctrine, the duty to not harm a neighbour. We also document cases in which the pollutee pays. These cases fall outside the nuisance doctrine either because they are international, so outside of domestic property rights regimes, or because the externality is not considered a nuisance under current legal interpretation.

Transaction costs are a frequent objection to applying Coase instead of Pigou. Harms are often diffused over many people, so that negotiating individual contracts would be impractical and costly. In practice, our review reveals that most substantive applications of Coase-like bargaining involve an entity acting on behalf of the aggregated interests of a large population, substantially reducing the transaction costs involved and solving the coordination problem between agents. These entities fall into two main categories – governments acting as agents of their people, and environmental groups acting on behalf of their members.

One caveat is that we do not know how many Coasian bargains would be struck in a world with different rules about compensation. In

many countries, laws codify not just property rights but also how much compensation must be paid if those property rights are violated.

Coase's central insight is that people, organizations, and countries can bargain over externalities to produce Pareto improvements if property rights are well defined, contracts are enforced, and transaction costs are relatively small. This theoretical result has been borne out in laboratory studies, showing that some of its strict conditions can be relaxed without materially affecting its key features. The practical importance of the result for addressing environmental problems is less clear. Although our review uncovered several cases of Coasian bargains being struck "in the wild", these generally appear limited in application, except in the international context, and are generally a complement to, rather than a substitute for, other forms of environmental regulation.

Conflict of interest

The authors declare no conflict of interest.

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Appendix A. Supplementary data

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