A Close Look at the Coase Theorem[0]

John S. Chipman

Since the publication of Keynes's *General Theory*, few works have had such a profound influence on economic thought as Coase's "The Problem of Social Cost" (1960). Presented, as are most new ideas, in a simplified and unequivocal manner, Coase's thesis has been aptly described by Calabresi (1968, p. 73) as a "Say's law of welfare economics". Exaggerated claims have been made for it by some authors (e.g., Stigler 1966, p. 113), while it has been scoffed at by others (e.g., Samuelson, 1995). In the present paper my aim is to provide a close scientific critique of Coase's doctrine, which is undoubtedly already being absorbed into the main body of economic theory. It raises questions that cannot be ignored, and even if the conclusions are not accepted without considerable modification, its influence will undoubtedly be permanent.

In section 1 I survey what I conceive to be the most important issues that have been raised in the literature: (1) the optimal forms of property rights and liability rules; (2) the extent to which private negotiation over the purchase and sale of such rights can be expected to lead to a Pareto-optimal outcome; and (3) the conditions under which Coase's proposition—that the level of pollution will be independent of the assignment of property rights to the various parties—is true. The remaining two sections concentrate on a close analysis of (3). Section 2 goes into Hurwicz's formulation in terms of a model of pure exchange, and section 3 into Dolbear's formulation which allows for a production-transformation relation between the two commodities. These sections illustrate that when externalities affect consumers directly rather than firms, the Coase proposition holds if and only if preferences are "parallel" in the sense that the demand for pollution rights is independent of income and income is always high enough to sustain this demand. Examples are provided both of cases of nonparallel preferences and cases of parallel preferences in which the income constraint fails to hold in which the "Coase theorem" fails to hold. Section 4 concludes.

[0]From James M. Buchanan and Bettina Monissen (eds.), *The Economists' Vision. Essays in Modern Economic Perspectives*. Frankfurt am Main: Campus Verlag, 1998, pp. 131–162.

1 General discussion

The greatest novelty of Coase's contribution was the systematic treatment of trade in property rights. In the earlier literature discussion of trade in property rights was confined largely to German economists.[1] This discussion did not, however, include pollution rights. Böhm-Bawerk (1881, p. 7; 1962, p. 36) obviously did not have pollution in mind or he could not have stated that "there is simply no such thing as a negative good, or a minus-quantity good, any more than there are negative or minus-quantity material things."[2] He asserted that (1881, p. 42; 1962, p. 59):

> . . . a legal right or the legalized power of disposal over a thing is nothing more nor less than a necessary reinforcement supplied by a politically organized state of the physical power which is needed by the owner of a good as a condition to its economic utilization.

This may be contrasted with the point of view of McKean (1970, p. 11):

[1]Hermann (1832, pp. 2, 7, 289) introduced a third class of goods (in addition to material goods and services) which he described as "relationships" (*Verhältnisse*). In this he was followed by Schmitthenner (1839, p. 380), who called them "quasi-capital"; by Roscher (1854, §3, pp. 3–4), who described them as "relations to persons or things"; by Hasner (1860, §136, p. 205); by Schäffle (1867a, 1867b), who studied goodwill (*Kundschaft*), patents, firm names, copyrights, etc.; and by Menger (1871, pp. 6–7; 1950, pp. 54–5). Among English-language writers, Macleod (1858, Ch. III) is virtually the only one to include rights among goods.

[2]Even when considering some truly detrimental phenomena Böhm-Bawerk went through the following puzzling circumlocutions (1881, p. 143; 1962, p. 131):

> The fact that a price is paid, or that costs are incurred to bring about a forbearance, by no means makes the latter a *good*. On the contrary, the payment merely represents the rendering indifferent of a factor which would otherwise be disadvantageous. If, for instance, a ring of pitch is applied around the trunk of a fruit tree to protect the fruit from ants and caterpillars, that ring of pitch is admittedly a good but the caterpillars and ants, now rendered innocuous, do not become goods. The same can be said of dikes, which are goods, but the prevented floods are not goods. . . . The concept of a good must be limited to positive factors for the attainment of an economic advantage.

> The basic things that we exchange are not products' physical features as such but rather packages of rights to do things with those features.

Arrow (1969) in a fundamental paper—see also the treatment by Wheaton (1972)—showed that externalities could be internalized if one distinguished goods by three subscripts: thus, to consider an example to be treated in section 3, x_{jik} denotes the consumption by individual j of individual k's consumption of commodity i (heat)—this is identified as j's involuntary consumption of smoke; and the marginal utility of this commodity to individual j is to be set proportional to a price p_{jik}. Further, in accordance with Samuelson's theory of public goods (1954), the sum of these "personalized prices" over the n individuals must equal one and the same price q_k. In this formulation, the number of commodities is not just doubled (which worried Böhm-Bawerk in his criticism of Macleod) but increased from m to mn^2 where n is the number of individuals. Arrow noted, however, that each commodity (j, i, k) has but one buyer (j) and one seller (i)—which is as thin as a market can be. Thus one cannot expect there to be forces driving it to a competitive equilibrium. Furthermore, it was subsequently shown by Starrett (1972) that such markets are characterized by "fundamental nonconvexities" that may preclude existence of competitive equilibrium, and in Starrett and Zeckhauser (1974) this was applied to Coase's rancher-farmer example.

In the following subsection I would like to consider the question, most ably treated by Calabresi and Mellamed (1972) and Rothbard (1982), of the optimal form that property rights should take.

1.1 Property rights and liability rules

One of the most striking things about the first example employed by Coase (1960)—that of the rancher and farmer—is that it constitutes the most extreme form of detrimental externality imaginable. The rancher allows his cattle to trample on the fields of his neighboring farmer; we may suppose that this takes place in a well-defined portion of the farmer's land. If the rancher is liable for damage done to the farmer, and there is perfect knowledge concerning the extent of the damage in terms of the pecuniary loss to the farmer, then the rancher must reimburse the farmer and this reimbursement is simply added to his production costs, and the externality is internalized. On the other hand, if the rancher is not liable

for the damage, the farmer must either bribe the rancher to confine his cattle to his own property, or acquiesce to the intrusion; in either case he suffers a loss that is identical with the loss that would be incurred if the rancher simply expropriated that portion of the farmer's land taken over by the cattle. The bribe or compensation that the farmer must pay to the rancher in order to exclude his cattle may be thought of rent payment for the portion of land expropriated by the rancher.

If both rancher and farmer rent their land from, say, a common landlord, and the rancher is not liable for the damage to the farmer, and if both had been breaking even previously to the incursion, then the farmer's payment to the rancher may be considered a sublease; either in this case or in the case in which the farmer acquiesces to the incursion, he now incurs a loss, and so would any other lessee; consequently the landlord has no choice but to reduce his rent. For the same reason he will increase the rancher's rent. But if the rancher were liable for the damage, there would be no need for either the rancher's or farmer's rent to change.

If the rancher is not liable for the damage, it may well be asked: what rights does the owner of the farmer's property have? Presumably none at all, since logically the rancher could expropriate all his land. In most examples of externality, the property owner retains some rights. If a neighbor builds a house that obstructs his view of a lake or mountain, he still retains control over the property, though its value is reduced. Similarly if a neighbor pollutes his air with smoke or noise. But in Coase's example, the neighbor has the power to reduce the value of the farmer's property to zero.

Coase does not take a moral position as to the "just" allocation of property rights, though his apparent indifference with respect to this allocation has been met by outrage on the part of some of his readers.[3] What is usually called the *Coase theorem* is the proposition that the level of the externality will be the same regardless of the assignment of property rights—we shall examine this proposition below. Coase also bases

[3]Thus, North (1992, p. xv) writes: "R. H. Coase's theorem constitutes one of the most subtle yet profound attacks ever written on the concept of private property rights. ...this relatively recent academic subdiscipline is grounded on a concept of law which is at odds with the moral and legal foundations of liberty." Further (p. 81): "By elevating the 'right to inflict damage' to the same level as the right to demand compensation for a violation of a property right, Coase has effectively compromised the latter right by making a potential right out of the ability to inflict damage."

himself on the proposition that voluntary negotiations over externalities will lead to a Pareto-optimal outcome. Consequently he adopts as his criterion of optimality the following (1960, p. 34):

> When an economist is comparing alternative social arrangements, the proper procedure is to compare the total social product yielded by these different arrangements.

There are two strong reservations that may be lodged against this criterion: (1) unless there is a single factor of production (leading to a labor theory of value), different social arrangements will correspond to different relative prices, hence the values of the social product in two social situations will be incomparable; and pairwise comparison of two social situations using one situation's prices may be inconsistent with pairwise comparison using the other situation's prices; (2) even ignoring the latter problem, two social arrangements (as Coase readily admits) may have substantial differences in income distribution. The criterion may therefore be described as "ultra-Kaldorian" in that distributive effects are ignored (cf. Kaldor, 1939). This stance—that of the "new welfare economics"—has the appearance of being value-free but is not.

A cogent critique of Coase's view of externality has been argued by Rothbard (1982), using the following illustration (p. 61):

> [Suppose] A is a successful seller of razor blades. But then B comes along and sells a better blade, teflon-coated to prevent shaving cuts. The value of A's property is greatly affected. Should he be able to collect damages from B, or, better yet, to enjoin B's sale of a better blade?

One might add, in case A does not have the rights posited, should he be allowed to bribe B to withdraw his product from the market? Rothbard's answer is (p. 62):

> Everyone has the right to have the physical integrity of his property inviolate; no one has the right to protect the value of his property, for that value is purely the reflection of what people are willing to pay for it.

Violation of the physical integrity of a property presumably implies reduction in its value; whether the legal distinction can always be made

I do not feel qualified to say, but some such distinction seems clearly essential. Otherwise, any disturbance to equilibrium could be classified as an externality. Indeed, this seems to be the interpretation of Demsetz (1966).

I have said that from the Coasian point of view, the expropriation (in effect) of other peoples' property is not to be condemned so long as it does not reduce the value of social income (see also Randall, 1974). Indeed, this position has been explictly espoused by Tullock (1967) who measures the cost of theft by the increased cost of defensive (for the victims—offensive for the thieves) weapons, burglar alarms, etc. Suppose, however, that these costs were negligible or could be ignored; who would invest in a business or a personal property with the knowledge that his investment is likely to be lost? The main rationale of private property rights is surely that the allocation of such rights to property owners is conducive to economic productivity and growth, whereas in the absence of such rights there is little prospect for an economy's success. In this broad sense, the so-called Coase theorem seems clearly contradicted by historical observation.

1.2 Is a market solution for externalities Pareto optimal?

Arrow (1979, p. 24) has remarked that the basic postulate underlying Coase's theory appears to be that the process of negotiation over property rights can be modelled as a cooperative game, and this requires the assumption that each player knows the preferences or production functions of each of the other players (whether individuals or firms). In answer to a similar criticism by Samuelson, Coase (1988a, pp. 160–2) appealed to the arguments of Edgeworth (1881); he conceded that negotiators need not end up on Edgeworth's contract curve but simply expressed the belief (p. 162) that "normally we would expect them to end up there." Thus this must be taken as Coase's hypothesis (not theorem). But there are several circumstances that have led a number of authors to question this conclusion.

1. The core may be empty, hence no Pareto optimum exists. An example of this for a three-agent model was presented by Aivazian and Callen (1981). They received a response from Coase (1981).

2. There may (as already mentioned) be a fundamental nonconvexity that prevents a Pareto optimum from being supported by a competitive equilibrium.

3. When there is one polluter and there are many pollutees, a "free-rider" problem arises and there is an incentive for pollutees to misrepresent their preferences. Whether the polluter is liable or not, the pollutees may be expected to overstate the amount they require to compensate for the externality (Arrow 1979, p. 25).

4. When an agent possesses the right to pollute, there is a built-in incentive for extortion. As Andel (1966) has pointed out, anyone with the right to pollute has an incentive to extract payment from potential pollutees, e.g., threatening to blow a bugle in the middle of the night. See Wellisz (1964), Shoup (1971), Daly and Giertz (1975, 1978), Bromley (1978), Demsetz (1971, 1978), Samuelson (1995).

Schweizer (1988) has modelled the externality problem as a noncooperative game with the Nash equilibrium as the solution concept, and concluded that (p. 246) "the Nash equilibrium has a fair chance of leading to an efficient outcome."

Hurwicz (1993) has considered formally the problem of enforcement of the rules of the game, when this enforcement uses up resources. The problem invlolves an obvious paradox, since while stricter enforcement (without consideration of enforcement costs) might bring the economy closer to Pareto optimality, the diversion of resources to enforcement would have the opposite effect. How one should define Pareto optimality in such a setup is a nice question. Demsetz (1969) has made some penetrating observations on similar questions related to transaction costs.

1.3 The neutrality theorem

Buchanan (1973b) has used the phrase "neutrality theorem" to distinguish the proposition that the amount of pollution is independent of the allocation of property rights. He has also distinguished between liability rules and property rights. Coase's own examples supporting this proposition have to do with negotiations between firms or businesses rather than those between individuals. The difference is important since firms

maximize profits rather than utility, and act as fiduciaries for individuals. In the case of consumers of two goods, one of which produces a detrimental externality, it has become clear in the writings of Dolbear (1967), Mishan (1971), Bromley (1978), and Hurwicz (1995) that Coase's neutrality theorem is a very special case that holds if and only if preferences of the consumers are "parallel" with respect to the private good, leading to absence of income effects in the demand for the (public) good with a detrimental externality; from an analysis that goes back to Edgeworth (1891) it follows that changes in income distribution will have no effect on the demand for the public good. This is examined in detail in the next two sections.

The problem may be illustrated by a variant of Coase's rancher-farmer example suggested by Block (1977). In Block's example, the farmer instead of raising corn for sale grows flowers for his own enjoyment (and his mother's memory). As Block poses the problem, the gardener without pollution-abatement rights will not have the wherewithal to bribe the rancher to desist from his pollution-producing activities.

Most of the discussion in the literature has concerned relationships between firms rather than individuals. Of course, a model with only firms (such as the example of the steel mill that generates a smoke nuisance to neighboring laundry establishments) is incomplete, since no account is taken of the consumers who purchase the steel products and laundry services. For discussion of this and similar cases see Turvey (1963), Portes (1970), Baumol (1972), and Gould (1977). An interesting interchange on upstream-downstream pollution problems is that of Kamien, Schwarz, and Dolbear (1966), Bramhall and Mills (1966), Tullock (1966), and Freeman (1967); see also Dick (1976). Likewise the interchange between Marchand and Russell (1973, 1975), Coelho, Gifford and Stone (1973, 1975), Greenwood *et al* (1975), as well as the recent analysis by Varian (1995).

2 Hurwicz's formulation

Suppose there are two individuals: individual 1 who is a smoker and enjoys smoking, and individual 2 who is a nonsmoker and is averse to smoke. Circumstances force them to work together in the same room. Each of the two individuals also enjoys the use of another commodity,

X, which will be called "money". Individual i's initial endowment of commodity X (money) is ξ_i, and his consumption of commodity X is denoted x_i; the total amount of money available to the two individuals is $\xi_1 + \xi_2 = \xi$. Let η_i denote individual i's initial endowment of commodity Y—legal rights (licenses) entitling the smoker to emit η_i units of smoke, these rights being limited to a total quantity of η units (i.e., $\eta_1 + \eta_2 = \eta$); individual i's final holdings of these rights is denoted y_i. Individual 1 must possess y_1 rights in order to have the permission to emit y_1 units of smoke, and can purchase such rights from individual 2 at a price p per right; in order to limit himelf to y_2 units of smoke, individual 2 may purchase $\eta - y_2$ rights from individual 1 at a price p per right. In an exchange equilibrium, the total amount of money held is $x_1 + x_2 = \xi$, while the total amount of pollution is $y_1 = y_2 = y$; that is, smoke—which for the smoker is a private good—is for the nonsmoker a public good—or rather, a public "bad".

Supposing the smoking rights to be tradable at a price of p units of commodity X ("money") per unit of commodity Y (smoking rights), the budget constraints for the respective individuals are

$$\begin{aligned} x_1 + py_1 &\leq \xi_1 + p\eta_1, \\ x_2 + p(\eta - y_2) &\leq \xi_2 + p\eta_2. \end{aligned} \tag{2.1}$$

($\eta - y_2$ may be interpreted as the amount of clean air consumed by individual 2, and η_2 may be interpreted as individual 2's initial endowment of rights to clean air). The aggregate budget constraint is given by

$$x_1 + x_2 + p\eta + p(y_1 - y_2) \leq \xi_1 + \xi_2 + p(\eta_1 + \eta_2).$$

Since commodity Y is a public good, $y_1 = y_2$, hence the above implies

$$x_1 + x_2 + p\eta \leq \xi + p\eta,$$

hence $x_1 + x_2 \leq \xi$, with equality attainable.

In the following two subsections, in order to give Coase the benefit of any doubt, we suppose it to be possible for our two individuals to trade money for pollution rights at a price p which is treated parametrically by both agents.

2.1 Nonparallel preferences

Let the utility functions of the two individuals be given by

$$\begin{aligned} U_1(x_1, y_1) &= x_1 y_1, \\ U_2(x_2, y_2) &= x_2(\eta - y_2). \end{aligned} \tag{2.2}$$

Both functions are strictly quasi-concave, U_1 being increasing in both arguments and U_2 increasing in x_2 and decreasing in y_2. We derive the two individuals' demand functions for x_i and y_i as functions of the price, p, of the licenses.

Individual 1's objective is to maximize $U_1(x_1, y_1) = x_1 y_1$ subject to the first constraint of (2.1). Equating the marginal rate of substitution to the price of a right, we have

$$\frac{\partial U_1/\partial y_1}{\partial U_1/\partial x_1} = \frac{x_1}{y_1} = p, \quad \text{hence } x_1 = p y_1. \tag{2.3}$$

Since equality must hold in the first constraint of (2.1), substituting (2.3) into this equality we obtain

$$\begin{aligned} 2x_1 &= \xi_1 + p\eta_1 \qquad \text{hence} \quad x_1 = \frac{\xi_1}{2} + \frac{\eta_1}{2} p; \\ 2py_1 &= \xi_1 + p\eta_1 \qquad \text{hence} \quad y_1 = \frac{\xi_1}{2p} + \frac{\eta_1}{2}. \end{aligned} \tag{2.4}$$

Individual 2's objective is to maximize $U_2(x_2, y_2) = x_2(\eta - y_2)$ subject

to the second constraint of (2.1), yielding the optimality condition[4]

$$-\frac{\partial U_2/\partial y_2}{\partial U_2/\partial x_2} = -\frac{-x_2}{\eta - y_2} = p \quad \text{hence } p(\eta - y_2) = x_2. \tag{2.5}$$

As before, the second budget constraint of (2.1) becomes an equality; substituting (2.5) into this equality we obtain

$$\begin{array}{rclcrcl} 2x_2 & = & \xi_2 + p\eta_2 & \text{hence} & x_2 & = & \dfrac{\xi_2}{2} + \dfrac{\eta_2}{2}p \\ 2p(\eta - y_2) & = & \xi_2 + p\eta_2 & \text{hence} & y_2 & = & \eta - \dfrac{\xi_2}{2p} - \dfrac{\eta_2}{2}. \end{array} \tag{2.6}$$

Summing the two individuals' demands for money from (2.4) and (2.6) and using the fact that $\xi_1 + \xi_2 = \xi$ and $\eta_1 + \eta_2 = \eta$ and the assumption that $x_1 + x_2 = \xi$, we have

$$\xi = x_1 + x_2 = \frac{\xi_1 + \xi_2}{2} + p\frac{\eta_1 + \eta_2}{2} = \frac{\xi}{2} + \frac{\eta}{2}p$$

from which it follows that $p = \xi/\eta$. Likewise, we must have $y_1 = y_2$ hence from (2.4) and (2.6) we have

$$0 = y_1 - y_2 = \frac{\xi_1 + \xi_2}{2p} + \frac{\eta_1 + \eta_2}{2} - \eta = \frac{\xi}{2p} - \frac{\eta}{2}$$

[4]Note that when one of the commodities is a "bad," the optimality condition is

$$-\frac{\partial U_2/\partial y_2}{\partial U_2/\partial x_2} = p.$$

This follows from the fact that the Lagrangean expression for the constrained-optimization problem is

$$L(x_2, y_2, \lambda) = U_2(x_2, y_2) - \lambda[x_2 + p(\eta - y_2) - \xi_2 - p\eta_2],$$

whence an interior solution requires

$$\begin{array}{rcl} \dfrac{\partial L}{\partial x_2} & = & \dfrac{\partial U_2}{\partial x_2} - \lambda = 0, \\ \dfrac{\partial L}{\partial y_2} & = & \dfrac{\partial U_2}{\partial y_2} + \lambda p = 0. \end{array}$$

Substituting the first of these equations into the second (to eliminate λ) we obtain

$$\frac{\partial U_2}{\partial y_2} + \frac{\partial U_2}{\partial x_2}p = 0 \quad \text{or} \quad -\frac{\partial U_2/\partial y_2}{\partial U_2/\partial x_2} = p.$$

from which it once again follows that $p = \xi/\eta$ (which must be the case, by Walras's law).

Evaluating the demand functions (2.4) and (2.6) at $p = \xi/\eta$ we obtain

$$\begin{aligned} x_1 &= \frac{\xi_1}{2} + \frac{\eta_1}{2}\frac{\xi}{\eta} \quad \text{and} \quad y_1 = \frac{\xi_1}{2}\frac{\eta}{\xi} + \frac{\eta_1}{2}; \\ x_2 &= \frac{\xi_2}{2} + \frac{\eta_2}{2}\frac{\xi}{\eta} \quad \text{and} \quad y_2 = \eta - \frac{\xi_2}{2}\frac{\eta}{\xi} - \frac{\eta_2}{2}, \end{aligned}$$

from which we verify that $x_1 + x_2 = \xi$ and $y_1 = y_2$. This is the desired competitive equilibrium.

Now let us consider two cases when the utility functions are as in (2.2). Let $\xi = \eta = 1$ and $\xi_1 = \xi_2 = \frac{1}{2}$. Then $p = 1$. In Case (i) the smoker (individual 1) starts out without any smoking rights ($\eta_1 = 0$) and ends up with $x_1 = \frac{1}{4}$ of the money (half of his initial amount, the other half of which is used to purchase smoking rights from the nonsmoker), and the right to smoke only $\frac{1}{4}$ of the time. On the other hand, in Case (ii) the smoker starts out with all the smoking rights ($\eta_1 = 1$) and ends up with $x_1 = \frac{3}{4}$ of the money ($\frac{1}{4}$ of which is obtained from selling smoking rights to the nonsmoker) and the right to smoke $\frac{3}{4}$ of the time. This violates the "Coase theorem" according to which the assignment of rights does not affect the amount of pollution.

2.2 Parallel preferences

Now let the utility functions of the two individuals be given by

$$U_1(x_1, y_1) = x_1 + \sqrt{y_1}, \quad \text{and} \quad U_2(x_2, y_2) = x_2 + \sqrt{\eta - y_2}. \tag{2.7}$$

This is a case of "parallel" preferences.[5]

We will examine the above two cases (i) and (ii) with these utility functions in place of the utility functions (2.2).

With the utility functions (2.7), (2.3) is replaced by

$$\frac{\partial U_1/\partial y_1}{\partial U_1/\partial x_1} = \frac{1}{2\sqrt{y_1}} = p \quad \text{hence } y_1 = \frac{1}{4p^2}. \tag{2.8}$$

[5]This assumption was first introduced by Auspitz and Lieben (1889, p. 465, formula (6), and pp. 470–478), and applied by Edgeworth (1891) to the two-consumer two-commodity pure-exchange problem. The concept was revived by Boulding (1945) who noted its importance in consumer's surplus analysis, and was referred to again by Samuelson (1964).

Thus, individual 1's demand for smoking rights is independent of income and of the budget constraint (so long as it is consistent with the budget constraint). Substituting (2.8) in the first budget constraint of (2.1) (with equality) we obtain the two demand functions for individual 1:

$$x_1 = \xi_1 + \eta_1 p - \frac{1}{4p} \quad \text{and} \quad y_1 = \frac{1}{4p^2}. \tag{2.9}$$

Turning to individual 2, (2.5) is replaced by

$$-\frac{\partial U_2/\partial y_2}{\partial U_2/\partial x_2} = \frac{1}{2\sqrt{\eta - y_2}} = p \quad \text{hence } y_2 = \eta - \frac{1}{4p^2}. \tag{2.10}$$

This is also independent of income and the budget constraint. Substituting (2.10) into the second budget constraint of (2.1) (with equality) we obtain the two demand functions for individual 2:

$$x_2 = \xi_2 + p\eta_2 - \frac{1}{4p} \quad \text{and} \quad y_2 = \eta - \frac{1}{4p^2}. \tag{2.11}$$

Now setting $x_1 + x_2 = \xi$ we have from (2.9) and (2.11)

$$\xi = x_1 + x_2 = \xi_1 + \xi_2 + (\eta_1 + \eta_2)p - \frac{1}{2p} = \xi + \eta p - \frac{1}{2p} \quad \text{hence} \quad p = \frac{1}{\sqrt{2\eta}}.$$

The same result is of course obtained by setting $y_1 = y_2$.

Substituting this price in the demand functions (2.9) and (2.11) we obtain

$$\begin{array}{rclcrcl} x_1 & = & \xi_1 + \dfrac{\eta_1}{\sqrt{2\eta}} - \dfrac{\sqrt{2\eta}}{4} & \text{and} & y_1 & = & \dfrac{\eta}{2}; \\ x_2 & = & \xi_2 + \dfrac{\eta_2}{\sqrt{2\eta}} - \dfrac{\sqrt{2\eta}}{4} & \text{and} & y_2 & = & \dfrac{\eta}{2} \end{array},$$

from which we verify that $x_1 + x_2 = \xi_1 + \xi_2$.

Now let us look as before at the special case $\xi = \eta = 1$ and $\xi_1 = \xi_2 = \frac{1}{2}$, and consider two cases. When the utility functions are as in (2.7), in Case (i), while the smoker starts out without any smoking rights ($\eta_1 = 0$) and ends up with $\frac{1}{2}(1 - \frac{1}{\sqrt{2}}) = 0.14645$ of the money (less than 30% of his initial amount, the other 70% of which is used to purchase smoking rights from the nonsmoker), he ends up with the right to smoke half the time. In Case (ii) the smoker starts out with all the smoking rights ($\eta_1 = 1$) and

ends up with $\frac{1}{2}(1+\frac{1}{\sqrt{2}}) = 0.85355$ of the money (more than 70% of his initial amount, the extra 0.35355 coming from the sale of smoking rights to the nonsmoker), but the right to smoke only half the time. This is in accord with the "Coase theorem" which states that the initial allocation of property rights does not affect the amount of pollution.

3 Dolbear's formulation

In a very ingenious article, Dolbear (1967) sought to model trade between two individuals of a private good for pollution rights when a simple production relation exists between the private good and the commodity producing pollution. Specifically, let bread be the private good desired by both individuals and let heat be the other good—desired by individual 1 but not individual 2—which produces smoke which is detrimental to individual 2. Denoting by x_i and y_i individual i's consumption of bread and heat/smoke respectively, and by x and y the total amounts respectively of bread and heat/smoke, we have

$$\begin{array}{rcl} x_1 + x_2 &=& x; \\ y_1 = y_2 &=& y; \\ x + \pi y &=& 1. \end{array} \tag{3.1}$$

Heat, being directly consumed only by individual 1 but directly affecting individual 2, is a public good, or rather "bad". It is assumed in the last equation of (3.1), as in the theory of public goods, that x may be transformed into y at constant cost.

As in (2.1) above, one might suppose the two individuals to have initial allocations (endowments) ξ_1 and ξ_2 of bread, as well as initial allocations η_1 and η_2 of rights to emission of smoke. We interpret η_i as the amount of rights held by individual i for individual 1 to emit η_i units of smoke. Defining $\xi = \xi_1 + \xi_2$ and $\eta = \eta_1 + \eta_2$, it would be natural to stipulate that $\xi + \pi\eta = 1$. Dolbear proceeds in a somewhat different way, however, distinguishing two stages: one in which the two individuals with endowments ξ_1 and ξ_2 of bread, depending on their allocation of pollution rights, trade bread for heat at the price π, and then with the new allocations between them of bread and heat/smoke proceed to to negotiate the exchange of bread for pollution rights. It should be emphasized that Dolbear (quite properly) does not assume

that this will be a competitive exchange; this is done in the following exposition, however, to concede a maximal number of assumptions to Coase.

3.1 Nonparallel preferences

Let us consider the simple case

$$\begin{aligned} U_1(x_1, y_1) &= x_1 y_1 \\ U_2(x_2, y_2) &= x_2(\eta - y_2), \end{aligned} \tag{3.2}$$

where η may be interpreted as an upper limit to the amount of smoke individual 2 can tolerate. This presupposes that the amount of smoke breathed by individual 2 can be measured exactly as the negative of the amount of heat consumed by individual 1,[6] where in equilibrium $y_1 = y_2 = y$. Production possibilities are described by the transformation function

$$F(x, y) = x + \pi y - 1 = 0. \tag{3.3}$$

Pareto optimality requires, by Samuelson's formula,[7]

$$\frac{\partial U_1/\partial y_1}{\partial U_1/\partial x_1} + \frac{\partial U_2/\partial y_2}{\partial U_2/\partial x_2} = \frac{\partial F/\partial y}{\partial F/\partial x}, \tag{3.4}$$

which in the present case reduces to

$$\frac{x_1}{y_1} - \frac{x_2}{\eta - y_2} = \pi. \tag{3.5}$$

As in the theory of public goods, it is assumed that initially no heat is produced, so that in accordance with (3.3) there is one unit of bread to be shared between the two individuals; thus, individual i starts out with an initial endowment of ξ_i units of bread (hence $\xi_1 + \xi_2 = 1$), and none of heat/smoke.

The technical problem posed by Dolbear may be interpreted as defining a set of preferences for individual 2 such that the problem reduces to one of pure exchange without production; thus, we are to find a net-utility function $\hat{U}_2(x_2, y_2)$ for individual 2 which has the property

$$\frac{\partial \hat{U}_2/\partial y_2}{\partial \hat{U}_2/\partial x_2} = \frac{\partial U_2/\partial y_2}{\partial U_2/\partial x_2} - \frac{\partial F/\partial y}{\partial F/\partial x}, \quad \text{so that} \quad \frac{\partial U_1/\partial y_1}{\partial U_1/\partial x_1} + \frac{\partial \hat{U}_2/\partial y_2}{\partial \hat{U}_2/\partial x_2} = 0,$$

[6] For a valuable generalization see Page and Ferejohn (1974).

[7] Samuelson (1954), also Bowen (1943) and Lindahl (1919).

or equivalently,

$$\frac{dx_2}{dy_2} = -\frac{\partial \hat{U}_2/\partial y_2}{\partial \hat{U}_2/\partial x_2} = \frac{x_2}{\eta - y_2} + \pi. \tag{3.6}$$

This is a standard linear differential equation of the first order (cf., e.g., El'sgol'ts 1962, pp. 14–15) whose general solution is

$$\hat{U}_2(x_2, y_2) = x_2(\eta - y_2) - \pi(\eta - \tfrac{1}{2}y_2)y_2 \tag{3.7}$$

The function $\hat{U}_2$ corresponds to Dolbear's "'fold-in' and 'stretch'" of the utility function U_2 (Dolbear 1967, p. 94) and to what Page and Ferejohn (1974, p. 457) describe as the "shear transformation" of U_2. As a behavioral hypothesis, maximization of $\hat{U}_2$ it seems rather hard to justify unless it can be assumed that individual 2 was able to solve the above integration problem; however, this seems a reasonable price to pay in order to incorporate production relations into the consumption externality problem.

We can imagine, following Coase's approach, that this pseudo-individual enters into a competitive exchange relation with individual 1 in which a market price is accepted parametrically by both. Let bread be the numéraire with price = 1, and let p denote the price of the right of individual 1 to consume one unit of heat and emit the corresponding one unit of smoke which, if possessed by individual 2, is interpreted as the right to compel individual 1 to refrain from consuming one unit of heat and emitting the corresponding one unit of smoke. Dolbear considers the polar cases in which: (i) individual 1 starts out possessing the sole right to emit any amount of smoke, and (ii) individual 2 starts out possessing the right to forbid the emission of any amount of smoke. In each case, the problem is divided into two stages: an initial stage (Stage 0) in which the parties trade at the price π, and a final stage (Stage 1) in which they negotiate over the pollution rights at a price p to be determined. In Stage 0, individual 2 maximizes U_2 whereas in Stage 1 he maximizes $\hat{U}_2$.

In Stage 0 of Case (i), individual 1 starts out by solving the problem

$$\text{Maximize}_{x_1, y_1}\, U_1(x_1, y_1) \text{ subject to } x_1 + \pi y_1 \leq \xi_1$$

where π is (initially) the market price of heat relative to bread and ξ_1 is individual 1's initial endowment of bread. Thus, individual 1 initially has the right to purchase any amounts of bread and heat satisfying the above

budget constraint. From the first utility function of (3.2) the solution of the above problem is clearly

$$x_1 = \xi_1/2, \quad y_1 = \xi_1/2\pi.$$

Since this leads to a total amount of smoke of $y = y_1 = \xi_1/2\pi$ which individual 2 does not want and must take as given, the available amount of bread, from (3.3), is $x = 1 - \pi y = 1 - \xi_1/2$ of which individual 1 consumes $x_1 = \xi_1/2$, leaving $1 - \xi_1/2 - \xi_1/2 = 1 - \xi_1 = \xi_2$ for individual 2, which is just the latter's endowment. Individual 1 therefore solves the trivial problem (taking y_2 as a parameter)

$$\text{Maximize}_{x_2}\, U_2(x_2, y_2) \text{ subject to } x_2 \leq \xi_2 = 1 - \xi_1.$$

The solution of this problem is obviously $x_2 = \xi_2 = 1 - \xi_1$.

The above gives rise to Stage 1 with a new "initial endowment" matrix

$$\begin{bmatrix} \omega_{11} & \omega_{12} \\ \omega_{21} & \omega_{22} \end{bmatrix} = \begin{bmatrix} \xi_1/2 & \xi_1/2\pi \\ 1 - \xi_1 & \xi_1/2\pi \end{bmatrix},$$

where ω_{ij} denotes individual i's new endowment in commodity j, from which the two players may start their negotiations over pollution rights. Let us suppose that a market price p for pollution rights (relative to bread) exists which both players accept parametrically. Then individual 1 must solve the following problem:

$$\text{Maximize}_{x_1, y_1}\, U(x_1, y_1) \text{ subject to}$$
$$x_1 + p y_1 \leq \omega_{11} + p\omega_{12} = \frac{\xi_1}{2}\left(1 + \frac{p}{\pi}\right).$$

This yields the demand functions

$$x_1 = \frac{\xi_1}{4}\left(1 + \frac{p}{\pi}\right), \quad y_1 = \frac{\xi_1}{4}\left(\frac{1}{p} + \frac{1}{\pi}\right). \tag{3.8}$$

Individual 2 now has an opportunity to purchase from individual 1 the right to compel individual 1 to desist from emitting $v_2 = \eta - y_2$ units of smoke, at a price of p per unit; he is currently (according to his initial endowment) forced to breathe $\xi_1/2\pi$ units of smoke. Accordingly, his budget constraint is

$$x_2 + p(\eta - y_2) \leq 1 - \xi_1 + p\frac{\xi_1}{2\pi}. \tag{3.9}$$

Individual 2, or rather, pseudo-individual 2, must therefore solve the problem:

$$\text{Maximize}_{x_2,y_2}\, \hat{U}_2(x_2, y_2) \text{ subject to}$$
$$x_2 + p(\eta - y_2) \leq \omega_{21} + p\omega_{22} = 1 - \xi_1 + \frac{\xi_1}{2}\frac{p}{\pi}.$$

Setting $-\partial\hat{U}_2/\partial y_2 = p\,\partial\hat{U}_2/\partial x_2$, it follows from (3.6) that

$$-x_2 + p(\eta - y_2) = \pi(\eta - y_2).$$

Adding this to the budget constraint (3.9) (with equality holding), we solve for y_2 and then x_2 to obtain pseudo-individual 2's demand functions

$$x_2 = \left(1 - \xi_1 + \frac{\xi_1 p}{2\pi}\right)\frac{p - \pi}{2p - \pi}, \quad y_2 = \eta - \frac{1 - \xi_1 + \xi_1 p/2\pi}{2p - \pi}. \tag{3.10}$$

Assuming both players to be price-takers, we may equate $y_1 = y_2 = y$ from (3.8) and (3.10) to obtain the following quadratic equation in p:

$$4(\xi_1 - 2\eta\pi)p^2 + (4 - 3\xi_1 + 4\eta\pi)\pi p - \pi^2\xi_1 = 0. \tag{3.11}$$

Since this is too complicated to yield an explicit solution, we may make the following assumptions:

$$\xi_1 = \tfrac{1}{2}; \quad \pi = \tfrac{1}{2}; \quad \eta = 1. \tag{3.12}$$

The quadratic equation (3.11) then reduces to

$$2p^2 - 2.25p + 1/8 = 0,$$

which has roots

$$p = 1.066391109 \quad \text{and} \quad p = 0.058608891. \tag{3.13}$$

Since reduction of the externality requires that it be made more expensive for individual 1, i.e., $p > \pi$, we take the larger root. From (3.10) we then obtain

$$x_2 = 0.358402223 \quad \text{and} \quad y_2 = 0.367217782,$$

while from (3.8) we obtain

$$x_1 = 0.391597777 \quad \text{and} \quad y_1 = 0.367217782.$$

Now we see a problem with Dolbear's model—or at least with my interpretation of it. While necessarily $y_1 = y_2$, as this condition was imposed, total output of bread is $x = x_1 + x_2 = 0.75$, which fails to satisfy the production constraint (3.3), since with the parameter values (3.12) and p as the first root of (3.13) we have $x + \pi y = 0.93368891 < 1$. Thus, unless I have made a mistake in calculations, or overlooked something in my interpretation of Dolbear's model, it seems to provide a less than watertight case for the propositions set forth.

Let us consider Case (ii). Individual 2 has all the pollution rights, hence in Stage 0 his problem is to

$$\text{Maximize}_{x_2,y_2} U_2(x_2, y_2) \text{ subject to } x_2 + \pi y_2 \leq \xi_2,$$

whose solution is $x_2 = \xi_2$ since he will wish to reduce smoke to its minimum, 0. On the other hand individual 1, who has no pollution rights, must

$$\text{Maximize}_{x_1} U_1(x_1, y_1) \text{ subject to } x_1 + \pi y_1 \leq \xi_1,$$

and since he must take y_1 as a parameter and individual 1 has chosen it to be zero, his solution is likewise $x_1 = \xi_1$. The endowment matrix for stage 1 is therefore

$$\begin{bmatrix} \omega_{11} & \omega_{12} \\ \omega_{21} & \omega_{22} \end{bmatrix} = \begin{bmatrix} \xi_1 & 0 \\ 1 - \xi_1 & 0 \end{bmatrix}.$$

In Stage 1, individual 1 must solve the problem

$$\text{Maximize}_{x_1,y_1} U_1(x_1, y_1) \text{ subject to } x_1 + py_1 \leq \omega_{11} + p\omega_{12} = \xi_1$$

whose solution is

$$x_1 = \frac{\xi_1}{2} \quad \text{and} \quad y_1 = \frac{\xi_1}{2p}.$$

Pseudo-individual 2 must solve the problem

$$\text{Maximize}_{x_2,y_2} \hat{U}_2(x_2, y_2) \text{ subject to } x_2 + py_2 \leq \omega_{21} + p\omega_{22} = 1 - \xi_1$$

whose solution is

$$x_2 = (1 - \xi_1)\frac{p - \pi}{2p - \pi}, \quad y_2 = \eta - \frac{1 - \xi_1}{2p - \pi}.$$

Equating y_2 to y_1 we obtain

$$p = \frac{\pi}{2} + \frac{1 - \xi_1}{2\eta - \xi_1}$$

which for the values (3.12) is 7/12. We then have

$$x_1 = \tfrac{1}{4}, \quad x_2 = \tfrac{1}{16}, \quad y_1 = y_2 = y = \tfrac{1}{4}$$

but

$$x + \pi y = \tfrac{5}{16} + \tfrac{1}{2} \cdot \tfrac{1}{4} = \tfrac{7}{16} < 1$$

as before.

In Case (ii), the amount of pollution is 1/4, whereas in Case (i) it is 0.3672, in opposition to the Coase Theorem.

3.2 Parallel preferences

Let us now take up the case of "parallel" preferences. Suppose the two individuals' utility functions have the "quasi-linear" form

$$\begin{aligned} U_1(x_1, y_1) &= x_1 + \sqrt{y_1}; \\ U_2(x_2, y_2) &= x_2 + \sqrt{\eta - y_2}. \end{aligned} \tag{3.14}$$

The condition for Pareto optimality is

$$\frac{\partial U_1/\partial y_1}{\partial U_1/\partial x_1} + \frac{\partial U_2/\partial y_2}{\partial U_2/\partial x_2} - \frac{\partial F/\partial y}{\partial F/\partial x} = \frac{1}{2\sqrt{y_1}} - \frac{1}{2\sqrt{\eta - y_2}} - \pi = 0.$$

We therefore seek a pseudo-utility function $\hat{U}_2(x_2, y_2)$ satisfying

$$\frac{dx_2}{dy_2} = -\frac{\partial \hat{U}_2/\partial y_2}{\partial \hat{U}_2/\partial x_2} = \frac{1}{2\sqrt{\eta - y_2}} + \pi. \tag{3.15}$$

The solution of this differential equation is

$$x_2 = -\sqrt{\eta - y_2} + \pi y_2 + \text{constant},$$

whence $\hat{U}_2$ is given by

$$\hat{U}_2(x_2, y_2) = x_2 + \sqrt{\eta - y_2} - \pi y_2. \tag{3.16}$$

From here one can proceed exactly as in the case of nonparallel preferences, equating the marginal rates of substitution of the utility functions (3.14) to the cost-price π to obtain for Case (i) the Stage-1 endowment matrix

$$\begin{bmatrix} \omega_{11} & \omega_{12} \\ \omega_{21} & \omega_{22} \end{bmatrix} = \begin{bmatrix} \xi_1 - \dfrac{1}{4\pi} & \dfrac{1}{4\pi^2} \\ 1 - \xi_1 & \dfrac{1}{4\pi^2} \end{bmatrix}.$$

Individual 1's problem then is to

$$\text{Maximize}_{x_1,y_1} U(x_1, y_1) = x_1 + \sqrt{y_1} \quad \text{subject to} \quad x_1 + py_1 \leq \frac{\xi_1}{2}\left(1 + \frac{p}{\pi}\right)$$

yielding the demand functions

$$x_1 = \frac{\xi_1}{2} + \frac{\xi_1 p}{2\pi} - \frac{1}{4p} \quad \text{and} \quad y_1 = \frac{1}{4p^2}. \tag{3.17}$$

Likewise for pseudo-individual 2,

$$\begin{aligned} &\text{Maximize}_{x_2,y_2} \hat{U}_2(x_2, y_2) = x_2 + \sqrt{\eta - y_2} - \pi y_2 \\ &\text{subject to} \quad x_2 + p(\eta - y_2) \leq 1 - \xi_1 + \frac{\xi_1 p}{2\pi} \end{aligned}$$

yielding the demand functions

$$x_2 = 1 - \xi_1 + \frac{\xi_1 p}{2\pi} - \frac{p}{4(p-\pi)^2} \quad \text{and} \quad y_2 = \eta - \frac{1}{4(p-\pi)^2}. \tag{3.18}$$

Equating y_1 and y_2 from (3.17) and (3.18) we obtain the quartic equation

$$4\eta p^4 - 8\eta\pi p^3 + (4\eta\pi^2 - 2)p^2 + 2\pi p - \pi^2 = 0.$$

Simplifying by taking $\eta = 1$ and $\pi = \frac{1}{2}$ this becomes

$$4p^4 - 4p^3 - p^2 + p - 0.25 = 0$$

which has one real root $p > \pi = 0.5$, namely $p = 1.06612094116$. Substituting this into the demand equations we get (with $\xi = \frac{1}{2}$)

$$\begin{aligned} x_1 &= 0.548565499 \qquad \text{and} \quad y_1 = 0.219951567, \\ x_2 &= 0.219951567 \qquad \text{and} \quad y_2 = 0.219951567, \end{aligned}$$

so that $y = 0.219951567$ and $x = x_1 + x_2 = 0.75$, whereas

$$x + \pi y = 0.859975783 < 1,$$

as before.

In Case (ii) the Stage-1 endowment matrix becomes exactly the same as that of subsection 3.1, and the respective maximization problems become

$$\text{Maximize}_{x_1,y_1}\, U_1(x_1, y_1) = x_1 + \sqrt{y_1} \quad \text{subject to} \quad x_1 + py_1 \leq \xi_1$$

and

$$\begin{gathered}\text{Maximize}_{x_2,y_2}\, \hat{U}_2(x_2, y_2) = x_2 + \sqrt{\eta - y_2} - \pi y_2 \\ \text{subject to} \quad x_2 + p(\eta - y_2) \leq 1 - \xi_1,\end{gathered}$$

leading to the demand functions

$$\begin{array}{llll} x_1 = \xi_1 - \dfrac{1}{4p} & \text{and} & y_1 = \dfrac{1}{4p^2} \\ x_2 = 1 - \xi_1 - \dfrac{p}{4(p-\pi)^2} & \text{and} & y_2 = \eta - \dfrac{1}{4(p-\pi)^2}. \end{array} \tag{3.19}$$

Notice that the demands for the externality are the same as in (3.17) and (3.18). Consequently, the same price p results, and we have

$$\begin{array}{rcrcrcr} x_1 & = & 0.765505028 & \text{and} & y_1 & = & 0.219951567, \\ x_2 & = & -0.331625970 & \text{and} & y_2 & = & 0.219951567, \end{array}$$

the negative value showing that the hypothesis of parallel preferences can hold only on a subset of the commodity space, and therefore in this case becomes an impossible hypothesis. Thus, the Coase theorem need not hold even with parallel preferences, because the parallel property can hold only for positive demands.

4 Concluding remarks

We conclude that the conditions under which Coase's neutrality theorem holds when consumption externalities are involved are very stringent indeed; the neutrality theorem (as in Coase's own examples) is best applied

to production externalities between firms, and even then, a number of exceptions have been noticed in the literature. And the hypothesis that negotiations over externalities will mimic trades in a competitive equilibrium is, as Coase himself has conceded, not one that can be logically derived from his assumptions, but must be regarded as an empirical conjecture that may or may not be confirmed from the data. A lot of theoretical work therefore still remains in order to provide Coasian economics with the same rigorous underpinnings as have been developed for Walrasian economics. The Coasian controversy will therefore be with us for some time to come, and this at least ensures that welfare economics is in no danger of becoming a dead subject. We can thank Coase for that.

References

Andel, Norbert (1966). "Some Notes on Equating Private and Social Cost: Comment." *Southern Economic Journal*, 33 (July), 112.

Aivazian, Varouj A. and Jeffrey L. Callen (1981). "The Coase Theorem and the Empty Core." *Journal of Law and Economics*, 24 (April), 175–181.

Arge, Ralph C. d' (1973). "Introduction" to the Coase Theorem Symposium. *Natural Resources Journal*, 13 (October), 557–560.

Arrow, Kenneth J. (1959). "Toward a Theory of Price Adjustment". In: Moses Abramowitz *et al.*, *The Allocation of Economic Resources: Essays in Honor of Bernard Francis Haley*. Stanford: Stanford University Press, 41–51.

Arrow, Kenneth J. (1969). "The Organization of Economic Activity: Issues Pertinent to the Choice of Market versus Nonmarket Allocation". In: *The Analysis and Evaluation of Public Expenditures: The PPB System. A Compendium of Papers Submitted to the Subcommittee on Economy in Government of the Joint Economic Committee, 91st Congress of the United States*, 1st Session, Vol. I, Part I, *The Appropriate Functions of Government in an Enterprise System*, Section A: *The Public Sector and the Public Interest: A Discussion of Basic Concepts*. Washington, D.C.: U.S. Government

Printing Office, 47–64. Reprinted as Arrow (1970). Abridged version reprinted in: Robert H. Haveman and Julius Margolis (eds.), *Public Expenditures and Policy Analysis*, Chicago: Markham Publishing Company, 1970, 59–73. Complete paper reprinted in: *The Collected Papers of Kenneth J. Arrow*, Vol. 2. Cambridge, Mass.: Harvard University Press, 1983, 133–154.

Arrow, Kenneth J. (1970). "Political and Economic Evaluation of Social Effects and Externalities." In: Julius Margolis (ed.), *The Analysis of Public Output*. New York: National Bureau of Economic Research and Columbia University Press, 1–23. Reprinted in M. D. Intriligator (ed.), *Frontiers of Quantitative Economics*. Amsterdam: North-Holland Publishing Company, 1971, 3–25.

Arrow, Kenneth J. (1979), "The Property Rights Doctrine and Demand Revelation under Incomplete Information." In: Michael J. Boskin (ed.), *Economics and Human Welfare: Essays in Honor of Tibor Scitovsky*, New York: Academic Press, 23–39.

Auspitz, Rudolf and Richard Lieben (1889). *Untersuchungen über die Theorie des Preises*. Leipzig: Verlag von Duncker & Humblot.

Auten, Gerald E. (1976). "The Problem of Social Cost: Fifteen Years Later: Discussion." In: Lin (1976), 37–40.

Bator, Francis (1958). "The Anatomy of Market Failure." *Quarterly Journal of Economics*, 72 (August), 351–379.

Baumol, William J. (1972). "On Taxation and Control of Externalities." *American Economic Review*, 62 (June), 307–322.

Baumol, William J. and David F. Bradford (1972). "Detrimental Externalities and Non-Convexity of the Production Set." *Economica*, New Series, 39 (May), 160–176.

Bergstrom, Theodore C. (1976). "Regulation of Externalities." *Journal of Public Economics*, 5 (January-February), 131–138.

Block, Walter (1977), "Coase and Demsetz on Private Property Rights." *Journal of Libertarian Studies*, 1 (No. 2), 111–115.

Böhm-Bawerk, Eugen von (1881). *Rechte und Verhältnisse vom Standpunkte der volkswirtschaftlichen Güterlehre.* Innsbruck: Verlag der Wagner'schen Universitäts-Buchhandlung. English translation: "Whether Legal Rights and Relationships are Economic Goods." In: *Shorter Classics of Eugen von Böhm-Bawerk*, Vol. I. South-Holland, Illinois: Libertarian Press, 1962, 25–138.

Boulding, Kenneth E. (1945). "The Concept of Economic Surplus." *American Economic Review*, 35 (December), 851–869.

Bowen, Howard R. (1943). "The Interpretation of Voting in the Allocation of Economic Resources." *Quarterly Journal of Economics*, 58 (November), 27–48.

Bramhall, David F. and Edwin S. Mills (1966). "A Note on the Asymmetry between Fees and Payments." *Water Resources Research*, 2 (No. 3), 615–616.

Bromley, Daniel W. (1978). "Externalities, Extortion, and Efficiency: Comment." *American Economic Review*, 68 (September), 730–735.

Buchanan, James M. (1962). "Politics, Policy, and the Pigovian Margins." *Economica*, New Series, 29 (February), 17–28.

Buchanan, James M. (1966). "Joint Supply, Externality and Optimality." *Economica*, New Series, 33 (November), 404–415.

Buchanan, James M. (1969). "External Economies, Corrective Taxes, and Market Structure." *American Economic Review*, 59 (March), 174–177.

Buchanan, James M. (1973a). "The Institutional Structure of Externality." *Public Choice*, 14 (Spring), 69–82

Buchanan, James M. (1973). "The Coase Theorem and the Theory of the State." *Natural Resources Journal*, 13 (October), 579–594.

Buchanan, James M. (1988). "Market Failure and Political Failure." *Cato Journal*, 8 (Spring-Summer), 1–13.

Buchanan, James M. and Wm. Craig Stubblebine (1962). "Externality." *Economica*, New Series, 29 (November), 371–384.

Buchanan, James M. and Wm. Craig Stubblebine (1972). "Pareto-Optimality and Gains-from-Trade: A Comment." *Economica*, New Series, 39 (May), 203–204.

Buchanan, James M. and Gordon Tullock (1962). *The Calculus of Consent. Logical Foundations of Constitutional Democracy.* Ann Arbor, Mich.: University of Michigan Press.

Burrows, Paul (1970). "On External Costs and the Visible Arm of the Law." *Oxford Economic Papers*, New Series, 22 (March), 39–56.

Calabresi, Guido (1965). "The Decision for Accidents: An Approach to Nonfault Allocation of Costs." *Harvard Law Review*, 78, 713–730.

Calabresi, Guido (1968). "Transaction Costs, Resource Allocation and Liability Rules—A Comment." *Journal of Law and Economics*, 11 (April), 67–73.

Calabresi, Guido and A. Douglas Melamed (1972). "Property Rules, Liability Rules and Inalienability: One View of the Cathedral." *Harvard Law Review*, 85 (April), 1089–1128.

Cheung, Steven N. S. (1969). "Transaction Costs, Risk Aversion and the Choice of Contractual Arrangements." *Journal of Law and Economics*, 12 (April), 23–42.

Cheung, Steven N. S. (1970). "The Structure of a Contract and the Theory of a Non-Exclusive Resource." *Journal of Law and Economics*, 13 (April), 49–70.

Cheung, Steven N. S. (1973). "The Fable of the Bees: An Economic Investigation." *Journal of Law and Economics*, 16 (April), 11–34.

Chipman, John S. (1965). "The Nature and Meaning of Equilibrium in Economic Theory." In: Don Martindale (ed.), *Functionalism and Its Limits in the Social Sciences*, Philadelphia: American Academy of Political and Social Science, Monograph 5 (February), 35–64. Reprinted in Harry Townsend (ed.), *Price Theory, Selected Readings*, Harmondsworth, Middlesex, England: Penguin Books Ltd., 1971, 341–371.

Chipman, John S. (1970). "External Economies of Scale and Competitive Equilibrium." *Quarterly Journal of Economics*, 84 (August), 347–385. Reprinted in James M. Buchanan and Yong J. Yoon (eds.), *The Return to Increasing Returns*. Ann Arbor: University of Michigan Press, 1994, 121–166.

Chipman, John S. and James C. Moore (1980). "Compensating Variation, Consumer's Surplus, and Welfare." *American Economic Review*, 70 (December), 933–949.

Clarke, Edward H. (1971). "Multipart Pricing of Public Goods." *Public Choice*, 11 (Fall), 17–33.

Clarke, Edward H. (1972). "Multipart Pricing of Public Goods: An Example." In: Selma J. Mushkin (ed.), *Public Prices for Public Products*, Washington, D.C.: The Urban Institute, 125–130.

Coase, Ronald H. (1937). "The Nature of the Firm." *Economica*, New Series, 4 (November), 386–405. Reprinted in Coase (1988b), 33–55.

Coase, Ronald H. (1959). "The Federal Communications Commission." *Journal of Law and Economics*, 2 (October), 1–40.

Coase, Ronald H. (1960). "The Problem of Social Cost." *Journal of Law and Economics*, 3 (October), 1–44. Reprinted in Coase (1988b), 95–156.

Coase, Ronald H. (1974). "The Lighthouse in Economics." *Journal of Law and Economics*, 17 (October), 357–376. Reprinted in Coase (1988b), 187–213.

Coase, Ronald H. (1981), "The Coase Theorem and the Empty Core: A Comment." *Journal of Law and Economics*, 24 (April), 183–187.

Coase, Ronald H. (1988a). "Notes on the Problem of Social Cost." In: Coase (1988b), 157–185.

Coase, Ronald H. (1988b). *The Firm, the Market, and the Law*. Chicago: The University of Chicago Press. vii, [1], 217 pp.

Coase, Ronald H. (1992). "The Institutional Structure of Production." *American Economic Review*, 82 (September), 713–719.

Coelho, Philip R. P. (1975). "Externalities, Separability, and Resource Allocation: Comment." *American Economic Review*, 65 (September), 721–723.

Cooter, Robert D. (1980). "How the Law Circumvents Starrett's Nonconvexity." *Journal of Economic Theory*, 22 (June), 499–504.

Cooter, Robert D. (1982). "The Cost of Coase." *Journal of Legal Studies*, 11 (January), 1–33.

Cooter, Robert D., Lewis Kornhauser, and David Lane (1979). "Liability Rules, Limited Information, and the Role of Precedent." *The Bell Journal of Economics*, 10 (Spring), 366–373.

Crocker, Thomas D. (1971). "Externalities, Property Rights and Transactions Costs: An Empirical Study." *Journal of Law and Economics*, 14 (October), 451–464.

Crocker, Thomas D. (1973). "Contractual Choice." *Natural Resources Journal*, 13 (October), 561–577.

Dalhman, Carl J. (1979). "The Problem of Externality." *Journal of Law and Economics*, 22 (April), 141–162.

Daly, George (1974). "The Coase Theorem: Assumptions, Applications and Ambiguities." *Economic Inquiry*, 12 (June), 203–213.

Daly, George and J. Fred Giertz (1975). "Externalities, Extortion, and Efficiency." *American Economic Review*, 65 (December), 997–1001.

Daly, George and J. Fred Giertz (1978). "Externalities, Extortion, and Efficiency: Reply." *American Economic Review*, 68 (September), 736–738.

Davis, Otto A. and Andrew B. Whinston (1962). "Externalities, Welfare, and the Theory of Games." *Journal of Political Economy*, 70 (June), 241–262.

Davis, Otto A. and Andrew B. Whinston (1965a). "Welfare Economics and the Theory of the Second Best." *Review of Economic Studies*, 32 (January), 1–14.

Davis, Otto A. and Andrew B. Whinston (1965b). "Some Notes on Equating Private and Social Cost." *Southern Economic Journal*, 32 (October), 113–126.

Davis, Otto A. and Andrew B. Whinston (1966). "On Externalities, Information and the Government-Assisted Invisible Hand." *Economica*, New Series, 33 (August), 303–318.

Davis, Otto A. and Andrew B. Whinston (1967). "On the Distinction between Public and Private Goods." *American Economic Review, Papers and Proceedings*, 57 (May), 360–373.

De Alessi, Louis (1980). "The Economics of Property Rights: A Review of the Evidence." *Research in Law and Economics*, 2, 1–47.

Demsetz, Harold (1964). "The Exchange and Enforcement of Property Rights." *Journal of Law and Economics*, 7 (October), 11–26.

Demsetz, Harold (1966). "Some Aspects of Property Rights." *Journal of Law and Economics*, 9 (October), 61–70.

Demsetz, Harold (1967). "Toward a Theory of Property Rights." *American Economic Review, Papers and Proceedings*, 57 (May), 347–359.

Demsetz, Harold (1969). "Information and Efficiency: Another Viewpoint." *Journal of Law and Economics*, 12 (April), 1–22.

Demsetz, Harold (1971). "Theoretical Efficiency in Pollution Control: Comment on Comments." *Western Economic Journal*, 9 (December), 444–446.

Demsetz, Harold (1972a). "When Does the Rule of Liability Matter?" *Journal of Legal Studies*, 1 (January), 13–28.

Demsetz, Harold (1972b). "Wealth Distribution and the Ownership of Rights." *Journal of Legal Studies*, 1 (June), 223–232.

Demsetz, Harold (1978). "On Extortion: A Reply." *American Economic Review*, 68 (June), 417–418.

De Quincey, Thomas (1844). *The Logic of Political Economy.* Edinburgh and London: William Blackwood and Sons.

Dick, Daniel T. (1976). "The Voluntary Approach to Externality Problems: A Survey of the Critics." *Journal of Environmental Economics and Management*, 2, 185–195.

Dolbear, F. Trenery, Jr. (1967). "On the Theory of Optimum Externality." *American Economic Review*, 57 (March), 90–103.

Dolbear, F. Trenery, Jr. (1968). "On the Theory of Optimum Externality: Reply." *American Economic Review*, 58 (June), 529–531.

Dolbear, F. Trenery, Jr. (1974). "Externalities as Commodities: Comment." *American Economic Review*, 64 (June), 451–453.

Edgeworth, F. Y. (1881). *Mathematical Psychics*. London: C. Kegan Paul & Co.

Edgeworth, F. Y. (1891). "Osservazioni sulla teoria matematica dell'economia politica con riguardo speciale ai principi di economia di Alfredo Marshall" and "Ancora a proposito della teoria del baratto". *Giornale degli Economisti*, Series 2, 2 (March), 233–245, (October), 316–318.

Eggertsson, Thrainn (1990). *Economic Behavior and Institutions*. Cambridge: Cambridge University Press.

El'sgol'ts, L. E. (1961). *Differential Equations*. Delhi: Hindustan Publishing Corporation (India), and New York: Gordon and Breach Science Publishers, Inc. [6], *iii*, iii, 359, [1] pp.

Epstein, Richard A. (1973). "A Theory of Strict Liability." *Journal of Legal Studies*, 2 (January), 151–204.

Farrell, M. J. (1959). "The Convexity Assumption in the Theory of Competitive Markets." *Journal of Political Economy*, 67 (August), 377–391.

Feldman, Roger (1974). "Liability Rules and the Transfer of Economic Rents." *Journal of Legal Studies*, 3 (June), 499–508.

Foley, Duncan K. (1967). "Resource Allocation and the Public Sector." *Yale Economic Essays*, 7 (Spring), 45–98.

Frech, H. E., III (1973). "Pricing of Pollution: The Coase Theorem in the Long Run." *The Bell Journal of Economics and Management Science*, 4 (Spring), 316–319.

Frech, H. E., III (1979). "The Extended Coase Theorem and Long-Run Equilibrium: The Nonequivalence of Liability Rules and Property Rights." *Economic Inquiry*, 17 (April), 254–268.

Freeman, A. Myrick, III (1967). "Bribes and Charges: Some Comments." *Water Resources Research*, 3 (No. 1), 287–288.

Freeman, A. Myrick, III (1971). "Distribution of Environmental Quality." In: A. V. Kneese and B. T. Bower (eds.), *Environmental Quality Analysis*. Baltimore: The Johns Hopkins Press for Resources for the Future, 243–278.

Furubotn, Eirik G. and Svetozar Pejovich (1972). "Property Rights and Economic Theory: A Survey of Recent Literature." *Journal of Economic Literature*, 10 (December), 1137–1162.

Gifford, Adam, Jr. (1974). "Externalities and the Coase Theorem: A Graphical Analysis." *Quarterly Review of Economics and Business*, 14 (Winter), 7–21.

Gifford, Adam, Jr. and Courtenay C. Stone (1973). "Externalities, Liability and the Coase Theorem: A Mathematical Analysis." *Western Economic Journal*, 11 (September), 260–269.

Gifford, Adam, Jr. and Courtenay C. Stone (1975). "Externalities, Separability, and Resource Allocation: Comment." *American Economic Review*, 65 (September), 724–727.

Goetz, Charles J. and James M. Buchanan (1971). "External Diseconomies in Competitive Supply." *American Economic Review*, 61 (December), 883–890.

Goldberg, Victor (1976a). "Towards an Expanded Economic Theory of Contract." *Journal of Economic Issues*, 10 (March), 45–61.

Goldberg, Victor (1976b). "Commons, Clark, and the Empirical Post-Coasian Law and Economics." *Journal of Economic Issues*, 10 (December), 877–893.

Goldberg, Victor (1981). "Pigou on Complex Contracts and Welfare Economics." *Research in Law and Economics*, 3 (February), 39–51.

Gordon, H. Scott (1954). "The Economic Theory of a Common Property Resource." *Journal of Political Economy*, 62 (April), 124–142.

Gould, J. R. (1977). "Total Conditions in the Analysis of External Effects." *Economic Journal*, 87 (September), 558–564.

Goursat, Edouard (1959). *A Course in Mathematical Analysis*, Vol. II, Part Two, *Differential Equations* (from the French, *Cours d'analyse mathématique*). New York: Dover Publications, Inc.

Green, Jerry R. and Jean-Jacques Laffont (1977a). "Characterization of Satisfactory Mechanisms for the Revelation of Preferences for Public Goods." *Econometrica*, 45 (March), 427–438.

Green, Jerry R. and Jean-Jacques Laffont (1977b). "Imperfect Personal Information and the Demand Revealing Process: A Sampling Approach." *Public Choice*, 29 (Spring) [Supplement], 79–94.

Green, Jerry R. and Jean-Jacques Laffont (1977c). "On the Revelation of Preferences for Public Goods." *Journal of Public Economics*, 8 (August), 79–93.

Green, Jerry R. and Jean-Jacques Laffont (1979). *Incentives in Public Decision-Making*. Amsterdam: North-Holland Publishing Company.

Greenwood, Peter, Charles Ingene, and James Horsfield (1975). "Externalities, Separability, and Resource Allocation: Comment." *American Economic Review*, 65 (September), 728–729.

Groves, Theodore (1973). "Incentives in Teams." *Econometrica*, 41 (July), 617–631.

Groves, Theodore (1976). "Information, Incentives, and the Internalization of Production Externalities." In: Lin (1976), 65–83.

Groves, Theodore and John O. Ledyard (1977a). "Optimal Allocation of Public Goods: A Solution to the 'Free Rider' Problem." *Econometrica*, 45 (May), 783–809.

Groves, Theodore and John O. Ledyard (1977b). "Some Limitations of Demand Revealing Processes." *Public Choice*, 29 (Spring) [Supplement], 107–124.

Groves, Theodore and Martin Loeb (1975). "Incentives and Public Inputs." *Journal of Public Economics*, 4 (August), 211–226.

Hasner, Leopold Ritter von (1860). *System der politischen Oekonomie*, Bd. 1. Prague: Verlag von F. A. Credner.

Heller, Walter P. and David A. Starrett (1976). "On the Nature of Externalities." In: Lin (1976), 9–22.

Hermann, Friedrich Benedikt Wilhelm von (1832). *Staatswirthschaftliche Untersuchungen*. Munich: in der Anton Weber'schen Buchhandlung. Facsimile reprint, Frankfurt/Main-Düsseldorf: Verlag Wirtschaft und Finanzen GmbH, 1987.

Hirshleifer, Jack (1973). "Exchange Theory: The Missing Chapter." *Western Economic Journal*, 11 (June), 129–146.

Hoffman, Elizabeth and Matthew L. Spitzer (1982). "The Coase Theorem: Some Experimental Tests." *Journal of Law and Economics*, 25 (April), 73–89.

Holtermann, Sally E. (1972). "Externalities and Public Goods." *Economica*, New Series, 39 (February), 78–87.

Hurwicz, Leonid (1972). "On Informationally Decentralized Systems." In: C. Bart McGuire and Roy Radner (eds.), *Decision and Organization*. Amsterdam: North-Holland Publishing Company, 297–336.

Hurwicz, Leonid (1979). "Outcome Functions Yielding Walrasian and Lindahl Allocations at Nash Equilibrium Points." *Review of Economic Studies*, 67 (April), 217–225.

Hurwicz, Leonid (1985). "A Perspective." In: Leonid Hurwicz, David Schmeidler, and Hugo Sonnenschein (eds.), *Social Goals and Social Organization*. Cambridge: Cambridge University Press, 1–16.

Hurwicz, Leonid (1993). "Implementation and Enforcement in Institutional Modeling." In: William A. Barnett, Melvin J. Hinich, and Norman Schofield (eds.), *Political Economy: Institutions, Competition, and Representation*. Cambridge and New York: Cambridge University Press, 51–59.

Hurwicz, Leonid (1995). "What is the Coase Theorem?" *Japan and the World Economy*, 7 (No. 1), 49–74.

Inada, Ken-ichi and Kiyoshi Kuga (1973). "Limitations of the 'Coase Theorem' on Liability Rules." *Journal of Economic Theory*, 6 (December), 606–613.

Johansen, Leif (1963). "Some Notes on the Lindahl Theory of Determination of Public Expenditures." *International Economic Review*, 4 (September), 346–358.

Johansen, Leif (1968). *Public Economics*. Amsterdam: North-Holland Publishing Company, and Chicago: Rand McNally & Company.

Johansen, Leif (1979). "The Bargaining Society and the Inefficiency of Bargaining." *Kyklos*, 32 (Fasc. 3), 497–522.

Kahneman, Daniel, Jack L. Knetch and Richard H. Thaler (1990). "Experimental Tests of the Endowment Effect and the Coase Theorem." *Journal of Political Economy*, 21 (December), 1325–1348.

Kaldor, Nicholas (1939). "Welfare Propositions in Economics and Interpersonal Comparisons of Utility." *Economic Journal*, 49 (September), 549–552.

Kamien, M. I., N. L. Schwarz, and F. T. Dolbear (1966). "Asymmetry between Bribes and Charges." *Water Resources Research*, 2 (No. 1), 147–157.

Kessel, Reuben A. (1974). "Transfused Blood, Serum Hepatitis, and the Coase Theorem." *Journal of Law and Economics*, 17 (October), 265–289.

Kneese, Allen V. (1962). *Water Pollution: Economic Aspects and Research Needs.* Washington, D.C.: Resources for the Future, Inc.

Kneese, Allen V. and Karl-Göran Mäler (1973). "Bribes and Charges in Pollution Control: An Aspect of the Coase Controversy." *Natural Resources Journal*, 13 (October), 705–716.

Knight, Frank H. (1924). "Some Fallacies in the Interpretation of Social Cost." *Quarterly Journal of Economics*, 38 (August), 582–606.

Kraus, Irving and Herbert Mohring (1975). "The Role of Pollutee Taxes in Externality Problems." *Economica*, New Series, 42 (May), 171–176.

Laffont, Jean-Jacques (1988). *Fundamentals of Public Economics*, Cambridge, Mass.: The MIT Press.

Liebhafsky, H. H. (1973), "'The Problem of Social Cost'—An Alternative Approach." *Natural Resources Journal*, 13 (October), 615–676.

Lin, Steven A. Y. (ed.) (1976). *Theory and Measurement of Economic Externalities.* New York: Academic Press.

Lin, Steven A. Y. and David K. Whitcomb (1976). "Externality Taxes and Subsidies." In: Lin (1976), 45–60.

Lindahl, Erik (1919), *Die Gerechtigheit der Besteuerung.* Lund: Gleerup. English translation of Part 1, Chapter 4, "Positive Lösung" (pp. 85–98): "Just Taxation—A Positive Solution." In: Musgrave and Peacock (1964), 168–176.

Luce, R. Duncan and Howard Raiffa (1957). *Games and Decisions.* New York: John Wiley & Sons, Inc.

Macleod, Henry Dunning (1858). *The Elements of Political Economy.* London: Longman, Brown, Green, Longmans and Roberts. XLIV, [2], 573 pp.

Marchand, James R. and Keith P. Russell (1973). "Externalities, Liability, Separability, and Resource Allocation." *American Economic Review*, 63 (September), 611–620.

Marchand, James R. and Keith P. Russell (1975). "Externalities, Liability, Separability, and Resource Allocation: Reply." *American Economic Review*, 65 (September), 730–732.

McKean, Roland N. (1970). "Products Liability: Implications of some Changing Property Rights." *Quarterly Journal of Economics*, 84 (November), 611–626.

Menger, Carl (1871), *Grundsätze der Volkswirthschaftslehre.* Wien: Wilhelm Braumüller. Facsimile reprint, Düsseldorf: Verlag Wirtschaft und Finanzen GmbH, 1990. English translation, *Principles of Economics*, Glencoe, Illinois: The Free Press, 1950.

Meyer, Robert A., Jr. (1971). "Externalities as Commodities." *American Economic Review*, 61 (September), 736–740.

Meyer, Robert A., Jr. (1974). "Externalities as Commodities: Reply." *American Economic Review*, 64 (June), 460–461.

Mishan, E. J. (1965). "Reflections on Recent Developments in the Concept of External Effects." *Canadian Journal of Economics*, 31 (February), 3–34.

Mishan, E. J. (1967). "Pareto Optimality and the Law." *Oxford Economic Papers*, New Series, 19 (November), 255–287.

Mishan, E. J. (1968), "On the Theory of Optimal Externality: Comment." *American Economic Review*, 58 (June), 523–527.

Mishan, E. J. (1969). "The Relationship between Joint Products, Collective Goods, and External Effects." *Journal of Political Economy*, 77 (May-June), 329–348.

Mishan, E. J. (1971). "The Postwar Literature on Externalities: An Interpretive Essay." *Journal of Economic Literature*, 9 (March), 1–28.

Monissen, Hans G. (1976). "Haftungsregeln und Allokation: Einige einfache analytische Zusammenhänge." *Jahrbuch für Sozialwissenschaft*, 27 (Heft 3), 391–412.

Musgrave, Richard Abel (1939). "The Voluntary Exchange Theory of Public Economy." *Quarterly Journal of Economics*, 53 (February), 213–237.

Musgrave, Richard A. (1959). *The Theory of Public Finance.* New York: McGraw-Hill Book Company.

Musgrave, Richard A. and Alan T. Peacock (eds.) (1964). *Classics in the Theory of Public Finance.* London: Macmillan & Co. Ltd.

Neumann, John von and Oskar Morgenstern (1947). *Theory of Games and Economic Behavior*, 2nd edition. Princeton, N.J.: Princeton University Press.

Newbery, David M. (1990). "Missing Markets: Consequences and Remedies." In: Frank H. Hahn (ed.), *The Economics of Missing Markets, Information, and Games.* Oxford: Clarendon Press, and New York: Oxford University Press, 211–242.

Ng, Yew-Kwang (1971). "Recent Developments in the Theory of Externality and the Pigovian Solution." *Economic Record*, 47 (June), 169–185.

Ng, Yew-Kwang (1975). "Coase's Theorem and First-Party-Priority Rule: Reply." *Economic Record*, 51 (June), 272–274.

Norgaard, Richard B. and Darwin C. Hall (1974). "Environmental Amenity Rights, Transactions Costs, and Technological Change." *Journal of Environmental Economics and Management*, 1 (December), 251–267.

North, Gary (1992). *The Coase Theorem.* Tyler, Texas: Institute for Christian Economics.

Nutter, G. Warren (1968). "The Coase Theorem on Social Cost: A Footnote." *Journal of Law and Economics*, 11 (October), 503–507.

Page, Talbot (1973). "Failure of Bribes and Standards for Pollution Abatement." *Natural Resources Journal*, 13 (October), 677–704.

Page, Talbot and John Ferejohn (1974). "Externalities as Commodities: Comment." *American Economic Review*, 64 (June), 454–459.

Pauly, Mark V. (1968). "On the Theory of Optimal Externality: Comment." *American Economic Review*, 58 (June), 528–529.

Pigou, A. C. (1920). *The Economics of Welfare*. London: Macmillan and Co. Ltd.

Plott, Charles R. (1966). "Externalities and Corrective Taxes." *Economica*, New Series, 33 (February), 84–87.

Portes, Richard (1970). "The Search for Efficiency in the Presence of Externalities." In: Paul Streeton (ed.), *Unfashionable Economics: Essays in Honour of Lord Balogh*. London: Weidenfeld and Nicolson, 348–361.

Posner, Richard A. (1973). "Strict Liability: A Comment." *Journal of Legal Studies*, 2 (January), 205–222.

Randall, Alan (1972). "Market Solutions to Externality Problems: Theory and Practice." *American Journal of Agricultural Economics*, 54 (May), 175–183.

Randall, Alan (1974). "Coasian Externality Theory in a Policy Context." *Natural Resources Journal*, 14 (January), 35–54.

Regan, Donald H. (1972). "The Problem of Social Cost Revisited." *Journal of Law and Economics*, 15 (October), 427–437.

Roberts, John (1976). "The Incentives for Correct Revelation of Preferences and the Number of Consumers." *Journal of Public Economics*, 6 (November), 359–374.

Roscher, Wilhelm (1854). *Die Grundlagen der Nationalökonomie*. Stuttgart and Tübingen: I. G. Cotta'scher Verlag.

Rothbard, Murray N. (1982). "Law, Property Rights, and Air Pollution." *Cato Journal*, 2 (Spring), 55–99.

Samuels, Warren J. (1974). "The Coase Theorem and the Study of Law and Economics." *Natural Resources Journal*, 14 (January), 1–34.

Samuelson, Paul A. (1954). "The Pure Theory of Public Expenditure." *Review of Economics and Statistics*, 36 (November), 387–389.

Samuelson, Paul A. (1955). "Diagrammatic Exposition of a Theory of Public Expenditure." *Review of Economics and Statistics*, 37 (November), 350–356.

Samuelson, Paul A. (1964). "Principles of Efficiency—Discussion." *American Economic Review, Papers and Proceedings*, 54 (May), 93–96.

Samuelson, Paul A. (1995). "Some Uneasyness with the Coase Theorem." *Japan and the World Economy*, 7 (No. 1) , 1–7.

Schäffle, Albert E. Fr. (1867a). "Die ausschliessenden 'Verhältnisse' mit besonderer Rücksich auf litterarisch-artistisches Autorrecht, Patent-, Muster- und Markenschuz." *Zeitschrift für die gesamte Staatswissenschaft*, 23, 143–218.

Schäffle, Albert E. Fr. (1867b). *Die nationalökonomische Theorie der ausschliessenden Absazverhältnisse, insbesondere des litterarisch-artistischen Urheberrechtes, des Patent-, Muster- und Firmenschuzes nebst Beiträgen zur Grundrentenlehre.* Tübingen: Verlag der H. Laupp'schen Buchhandlung.

Schmitthenner, Friedrich [Jacob] (1839). *Zwölf Bücher vom Staate, oder systematische Encyklopädie der Staatswissenschaften.* Erster Band. *Grundlinien der Geschichte der Staatswissenschaften, der Ethnologie, des Naturrechtes und der Nationalökonomie*, Zweite Auflage. Gießen: Druck und Verlag von Georg Friedrich Heyer, Vater.

Schulze, William and Ralph C. d'Arge (1974). "The Coase Proposition, Information Constraints, and Long-Run Equilibrium." *American Economic Review*, 64 (September), 763–772.

Schweizer, Urs (1988). "Externalities and the Coase Theorem: Hypothesis or Result?" *Journal of Institutional and Theoretical Economics – Zeitschrift für die gesamte Staatswissenschaft*, 144 (April), 245–266.

Schweizer, Urs (1990). "Calculus of Consent: A Game-Theoretic Perspective." *Journal of Institutional and Theoretical Economics – Zeitschrift für die gesamte Staatswissenschaft*, 146, 28–54.

Shapiro, David L. (1974). "A Note on Rent and the Coase Theorem." *Journal of Economic Theory*, 7 (January), 125–128.

Shapley, Lloyd S. (1976). "Noncooperative General Exchange." in: Lin (1976), 155–175.

Shapley, Lloyd S. and Martin Shubik (1969). "On the Core of an Economic System with Externalities." *American Economic Review*, 59 (September), 678–684.

Shibata, Hirofumi (1872). "Pareto-Optimality, Trade and the Pigovian Tax." *Economica*, New Series, 39 (May), 190–202.

Shoup, Donald C. (1971). "Theoretical Efficiency in Pollution Control: Comment." *Western Economic Journal*, 9 (September), 310–313.

Shubik, Martin (1959). "Edgeworth Market Games." In: A. W. Tucker and R. D. Luce (eds.), *Contributions to the Theory of Games*. Princeton, N. J.: Princeton University Press, 267–278.

Starrett, David A. (1972). "Fundamental Nonconvexities in the Theory of Externalities." *Journal of Economic Theory*, 4 (April), 180–199.

Starrett, David A. (1988). *Foundations of Public Economics*. Cambridge and New York: Cambridge University Press.

Starrett, David and Richard Zeckhauser (1974). "Treating External Diseconomies—Markets or Taxes?" In: John W. Pratt (ed.), *Statistical and Mathematical Aspects of Pollution Problems*. New York: Marcel Dekker, Inc., 65–84.

Stigler, George J. (1966). *The Theory of Price*, 3rd edition. London: Collier-Macmillan Limited.

Stigler, George J. (1989). "Two Notes on the Coase Theorem." *Yale Law Journal*, 99 (December), 631–633.

Swan, Peter L. (1975). "The Coase Theorem and 'Sequential' Pareto Optimality." *Economic Record*, 51 (June), 268–271.

Tideman, T. Nicolaus (1972). "The Efficient Provision of Public Goods." In: Selma J. Mushkin (ed.), *Public Prices for Public Products*. Washington, D.C.: The Urban Institute, 111–123.

Tideman, T. Nicolaus and Gordon Tullock (1976). "A New and Superior Process for Making Social Choices." *Journal of Political Economy*, 84 (December), 1145–1160.

Tullock, Gordon (1966). "Asymmetry Between Bribes and Charges: A Comment." *Water Resources Research*, 2 (No. 4), 854–855.

Tullock, Gordon (1967). "The Welfare Costs of Tariffs, Monopolies, and Theft." *Western Economic Journal*, 5 (June), 224–232.

Turvey, Ralph (1963). "On Divergences between Social Cost and Private Cost". *Economica*, New Series, 30 (August), 309–313.

Tybout, Richard A. (1972), "Pricing Pollution and Other Negative Externalities." *The Bell Journal of Economics and Management Science*, 3 (Spring), 252–266.

Tybout, Richard A. (1973), "Pricing of Pollution: Reply." *The Bell Journal of Economics and Management Science*, 4 (Spring), 320–321.

Uzawa, Hirofumi (1962). "On the Stability of Edgeworth's Barter Process." *International Economic Review*, 3 (May), 218–232.

Varian, Hal R. (1994). "A Solution to the Problem of Externalities when Agents are Well-Informed." *American Economic Review*, 84 (December), 1278–1293.

Varian, Hal R. (1995). "Coase, Competition, and Compensation." *Japan and the World Economy*, 7 (No. 1), 13–27.

Veljanowski, Čento G. (1977). "The Coase Theorem—The Says Law of Welfare Economics." *Economic Record*, 53 (December), 535–541.

Veljanowski, Čento G. (1982). "The Coase Theorems and the Economic Theory of Markets and Law." *Kyklos*, 35 (Fasc. 1), 53–74.

Walsh, Cliff (1972). "On Internalizing Externalities." *Economic Record*, 48 (June), 254–259.

Walsh, Cliff (1975). "First-Party-Priority Revisited." *Economic Record*, 51 (June), 275–277.

Wellisz, Stanislaw (1961). "On External Diseconomies and the Government-Assisted Invisible Hand." *Economica*, New Series, 31 (November), 345–362.

Wheaton, William C. (1972). "On the Possibility of a Market for Externalities." *Journal of Political Economy*, 80 (September-October), 1039–1044.

Whitcomb, David K. (1972). *Externalities and Welfare.* New York : Columbia University Press.

Wicksell, Knut (1896), *Finanztheoretische Untersuchungen*, Jena: Verlag von Gustav Fischer. Facsimile reprint, Düsseldorf: Verlag Wirtschaft und Finanzen, 1988. English translation of pp. iv–vi, 76–87, 101–159 from "Ueber ein neues Prinzip der gerechten Besteuerung": "A New Principle of Just Taxation." In: Musgrave and Peacock (1964), 72–118.

Williamson, Oliver E. (1979). "Transaction-Cost Economics: The Governance of Contractual Relations." *Journal of Law and Economics*, 22 (October), 233–261.

Williamson, Oliver E. (1981). "Contract Analysis: A Transaction Cost Approach." In: Paul Burrows and Čento G. Veljanowski (eds.), *The Economic Approach to Law.* London and Boston: Butterworths, 39–60.

Williamson, Oliver E. (1995). "Some Uneasiness with the Coase Theorem: Comment." *Japan and the World Economy*, 7 (No. 1), 9–11.

Wilson, Robert (1978). "A Competitive Model of Exchange." *Econometrica*, 46 (May), 577–585.

Zerbe, Richard O. (1970). "Theoretical Efficiency in Pollution Control." *Western Economic Journal*, 8 (December), 364–376.

Zerbe, Richard O. (1971). "Theoretical Efficiency in Pollution Control: Reply." *Western Economic Journal*, 9 (September), 314–317.

Zerbe, Richard O. (1976). "The Problem of Social Cost: Fifteen Years Later." In: Lin (1976), 29–36.

Zerbe, Richard O. (1980). "The Problem of Social Cost in Retrospect." *Research in Law and Economics*, 2, 83–102.