The Invisible Hand and Externalities

By Eric S. Maskin*

When economists contemplate the invisible hand at work, they generally think of competitive markets. But there are some circumstances in which markets are not supposed to operate well (i.e., in which the invisible hand is thought to falter). A leading cause of market failure, many argue, is the presence of significant externalities. With such externalities, the first welfare theorem does not apply, and so competitive equilibrium—if it exists at all—is not typically Pareto optimal. In the tradition of A. C. Pigou (1932), the typical response to this lack of optimality is for the government to step in and introduce corrective policy, usually in the form of taxes or subsidies.

There is, of course, a strong anti-Pigouvian tradition, as well. Specifically, proponents of the Coase theorem (Ronald Coase, 1960) have contended that, despite externalities, unrestrained bargaining and contracting ought to be sufficient to generate an efficient outcome. (Indeed Coase's own celebrated example was a case of externalities.) Thus, even if formal markets themselves fail, the invisible hand nevertheless succeeds, and outside intervention or design is not required.

Recently, Joseph Farrell (1987) argued that, even when free bargaining is permitted, the laissez-faire conclusion inherent in the Coase theorem may founder if agents have incomplete information about one another's relevant characteristics. I shall show, however, that the problem that Farrell identified is due only to monopoly power and is not peculiar to externalities.

Indeed, in this paper, I shall take a modified Coasian stance. I shall attempt to show that, in spite of externalities and incomplete information, private contractual agreements suffice to achieve efficiency, as long as no agent is big enough to have significant market power. This conclusion must be qualified, however, with the proviso that, if the externality is "nonexcludable" (i.e., no one can be excluded from its effects), the government must intervene to prevent free-riding on the agreements. Intervention, in this case, amounts to establishing the right of an agent providing a positive external effect to collect a fee for increasing the effect from all who enjoy it, *even if they are not parties to a contract* with the provider. Symmetrically, providers of a negative externality can collect a fee for diminishing the effect from all their victims. In either case, however, the fee is set *endogenously*, that is, it is determined by the contractual arrangements rather than by the government.

This result for nonexcludable externalities (which include pure public goods) provides support for a fairly laissez-faire stance toward externalities but turns on an important assumption, namely, that parties always write contracts so as to maximize their social surplus (subject to incentive and individual-rationality constraints). I will return to this assumption in the final section.

I. Bees and Trees

Let me invoke James Meade's (1952) famous example, that of the beekeeper and the apple-grower, to illustrate the issues posed by externalities. When the beekeeper's bees fly into the adjoining apple orchard and pollinate the apple-grower's apple blossoms, they are conferring a positive benefit on the apple-grower that the beekeeper cannot take advantage of directly (i.e., a positive externality). The beekeeper's inability to capture the value created by her bees means that she will tend to keep too

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few of them from a social standpoint. But there is a simple Coasian solution to this problem, namely, the two parties can negotiate a fee to be paid by the apple-grower to the beekeeper to induce her to keep the efficient number of bees. If such a deal comes off, there is no need for any outside interference or corrective policy.

Now, one potential stumbling block for a contract like this is that the apple-grower may be ignorant of the beekeeper's technology and so may not know the fee level that would induce her to increase her operation by the marginal bee. Even so, if the apple-grower offered a fee f just equal to his marginal benefit, b, from the increase, efficiency would be attained, since the beekeeper would accept f if (and only if) it exceeded c, her marginal cost of beekeeping (net of the price at which she can sell bees). But, in this case, the apple-grower's net marginal benefit $b-f$ would be zero. What a rational apple-grower will do, therefore, is to "shade" his offer somewhat, that is, to set f strictly less than b. This means that, if it turns out that $b>c>f$, then the additional bee will *not* be kept even though it would have been efficient (in the sense of increasing social surplus) to do so. The same logic works symmetrically for the case in which it is the beekeeper who proposes f. Her net payoff will be positive only if f is higher than c. Thus, if she is uncertain about b, she may well set f higher than b, thereby preventing a deal even though b exceeds c. In either case, there is positive probability that the outcome will not be efficient[1] (again, in the social surplus sense).[2]

Farrell (1987) argued that this inefficiency of negotiated agreements under incomplete information constitutes a counterexample to the Coase theorem. Indeed, he pointed out, there is a definite role for policy intervention, since the government can restore *ex ante* efficiency by, for example, imposing a scheme à la Claude d'Aspremont and Louis-André Gérard-Varet (1979) (albeit at the cost of possibly leaving one of the two parties worse off than were there no agreement at all).

The sort of inefficiency that the bee–apple example illustrates is not at all special to externalities. It is symptomatic of *any* situation in which there is monopoly power and incomplete information. In the example, the apple-grower is a monopsonist in "pollination services" and is therefore able to negotiate a fee for these services that is lower than his marginal benefit. Furthermore, the same would be true—and, therefore, the same inefficiency would arise—if pollination services were an ordinary private good, and not an external effect created by beekeeping.

Because it is not evident that situations entailing externalities are significantly more prone to the exercise of monopoly power than those involving purely private goods, a fairer test of whether externalities pose a particular problem for the invisible hand is one in which monopoly power (but not incomplete information) is kept out of the picture.

[1] In fact, the same result also holds for range of intermediate cases in which the fee is jointly determined by the apple-grower and the beekeeper (see Jean-Jacques Laffont and Maskin, 1979; Roger Myerson and Mark Satterthwaite, 1983).

[2] Whether the beekeeper or apple-grower sets the fee, however, the resulting contract *is* Pareto efficient in the interim sense. That is, there is no other contract for which it is common knowledge that both parties would be better off (otherwise, the fee-setter would propose such a contract). When I say that the contract is inefficient, therefore, I am invoking the stronger concept of surplus-maximization, which here is the same as *ex ante* efficiency (a contract is *ex ante* efficient if there is no other contract that makes both parties better off in expectation, where the expectation is taken over both their "types," b being the apple-grower's type and c the beekeeper's). The rationale for using the stronger concept is the supposition that situations involving externalities occur repeatedly and that, over time, agents are more or less symmetric with respect to them. That is, in a dynamic economy, sometimes an agent creates an externality, and sometimes he is its beneficiary. Sometimes he is affected a great deal by an externality, and sometimes only slightly. The presumption behind *ex ante* efficiency as a welfare criterion is that all agents are basically the same in this respect.

II. Many Bees and Trees

Imagine then that there are n beekeepers and n apple-growers and that the two groups are adjacent to one another. Each beekeeper j ($j=1,\dots,n$) is described by the cost c_j that she incurs from keeping an additional bee. The parameter c_j is private information and, for concreteness, is assumed to be an independent draw from the uniform distribution on [1,3]. Each apple-grower i is described by his utility function $\theta_i x - x^2$, where x is the number of bees from whose services the apple-grower benefits. Like the c_j's, the θ_i's are identical and independently distributed according to the uniform distribution on [1,3].

Assume, for the moment, that a beekeeper can control where her bee goes (i.e., whose blossoms it pollinates). This means that the beekeeper can *exclude* any apple-grower from enjoying the bee's external effect unless he pays a fee. Under this assumption, pollination services turn out to differ little from an ordinary private good (even though an apple-grower has no direct control over x). Given the realizations of the θ_i's and c_j's, the unique surplus-maximizing allocation of services can be described as follows. For any "price" p, let

$$s(c_j,p)=\begin{cases}1 & \text{if } c_j \le p\\ 0 & \text{if } c_j > p\end{cases}$$

and

$$d(\theta_i,p)=\max\left\{\frac{\theta_i-p}{2},0\right\}.$$

Then, beekeeper j should keep $s(c_j,\hat{p})$ additional bees, and apple-grower i should receive services equal to $d(\theta_i,\hat{p})$, where $\hat{p}$ satisfies

$$(1)\qquad \frac{1}{n}\sum_{i=1}^{n} d(\theta_i,\hat{p})=\frac{1}{n}\sum_{j=1}^{n} s(c_j,\hat{p}).$$

If n is large, however, the strong law of large numbers implies that, with high probability, (1) is very nearly the same as

$$(2)\qquad E\left[d\left(\tilde{\theta}_i,\hat{p}\right)\right]=\Pr\left\{s\left(\tilde{c}_j,\hat{p}\right)=1\right\}$$

where E denotes the expectation with respect to $\tilde{\theta}$ and Pr denotes "probability of." Now, the solution to (2) is $\hat{p}=5-2\sqrt{3}$. Hence, there exists a simple contract between the apple-growers and beekeepers that is nearly efficient despite the incompleteness of information: first, each apple-grower demands the level of pollination services he wishes at the price $5-2\sqrt{3}$, and simultaneously each beekeeper proposes whether she will keep an additional bee (i.e., be a "do-beekeeper") or not (i.e., be a "don't-beekeeper") if paid the price $5-2\sqrt{3}$. In view of the strong law, almost everybody will get to carry out his or her proposal. However, to equate supply and demand, either a small fraction of do-beekeepers must be chosen at random and proscribed from keeping an additional bee, or else some don't-beekeepers must be selected and compelled to keep an additional bee.

Observe that no government intervention at all is required to attain an efficient outcome here. It is worth noting why this is so. Even diehard Coasians acknowledge that there *is* an active role for government in dealing with externalities, namely, to establish "property rights." But establishing a property right in pollination services is not necessary because I have posited that beekeepers have the power of exclusion. This ability prevents an apple-grower from free-riding on an agreement made by others. Since, as I will argue, the purpose of creating an ownership right in pollination services is precisely to curtail free-riding, such a right is superfluous here.

III. The Nonexcludable Case

Suppose that beekeepers cannot control their bees. Symmetry then implies that each bee provides (in expectation) $1/n$ units of pollination services to every apple-grower. For surplus maximization, beekeeper j

should keep an additional bee as long as

$$(3) \qquad \frac{1}{n}\sum_{i=1}^{n}(\theta_i - 2x) > c_j.$$

Thus, if n is large, it will be nearly efficient for beekeeper j to keep the additional bee whenever $c_j < \frac{3}{2}$ and for each apple-grower to enjoy approximately $\frac{1}{4}$ units of pollination services in all. Notice that this approximate figure of $\frac{1}{4}$ is independent of any single apple-grower's θ_i. Therefore, if n is large, an incentive-compatible and efficient contract would require every apple-grower to pay approximately the same amount (which would come to at least $\frac{1}{4} \times \frac{5}{4} = \frac{5}{16}$, since the average cost incurred by those beekeepers who keep an extra bee is $\frac{5}{4}$, and approximately one-quarter of all beekeepers do so). An apple-grower, therefore, has a strong incentive to refrain from signing any agreement. By standing apart, he can avoid paying anything and still enjoy approximately the same level of pollination services as when he participates. (Because the apple-grower does not appreciably affect the efficient allocation of pollination services, the beekeepers and other apple-growers will sign much the same agreement without him as with him). In other words, he can "free-ride" on the other agents' contract.

This is where the government steps in. What it can do is to endow beekeepers with the property right to their bees' pollination services. Such a right entitles a beekeeper to a fee from each apple-grower who enjoys pollination services. Now, of course, there is no reason why the government should know the expected marginal benefit from these services, and so it may be unable to set the fee appropriately. However, it can tie the fee to the fee-structure specified in the contract.

To be more concrete, suppose that, when n is large, agents sign a contract in which each beekeeper announces whether or not she is willing to keep an additional bee if paid the fee of $\frac{3}{2}$, and a number of apple-growers (approximately 75 percent) are selected at random to pay a fee of $\frac{1}{2}$ each. From the above analysis, this contract is known to be (nearly) surplus-maximizing. Assume that the government requires any nonparticipating apple-grower to pay the same fee that is specified in the contract. Then any apple-grower prefers to sign the contract, since if he does so he pays the fee with less than probability 1, and his pollination services are the same whether or not he signs.[3] I conclude, therefore, that the government-instituted property right stops free-riding.

I have been arguing the case of positive externalities, but a symmetric argument pertains to negative externalities. For that matter, the assumption that the θ_i's are independent draws can also be relaxed. When the θ_i's are independent, the strong law implies that one does not need to collect information about the sample distribution in order to approximate an efficient allocation. When the θ_i's are correlated, this may no longer be the case. However, if the contract incorporates a modified "Groves scheme" (Theodore Groves, 1973), whereby a sample of apple-growers is selected and each is induced to reveal his type, efficiency can again be (approximately) attained.

IV. Surplus-Maximizing Contracts

I have been assuming that agents choose surplus-maximizing (or nearly surplus-maximizing) contracts. This may be criticized as being at odds with the large-numbers assumption; presumably efficient contracting is more difficult with many agents. I am on comparatively safe ground with the case of excludable externalities, since contracts there resemble ordinary Walrasian markets. Moreover, it can be shown in this case that any sequence of interim-efficient, individually rational contracts converges to the Walrasian mechanism as $n \to \infty$.

[3] I am assuming here that, if the apple-grower does not participate, the other agents will sign more or less the same contract: one that is (approximately) surplus-maximizing. These other agents may all gain, however, from signing a contract that exploits the fact that his fee is at their mercy. Of course, this will make the apple-grower all the more willing to participate.

There are two problems with nonexcludable externalities. First, as I have shown, the surplus-maximizing contract does *not* resemble a Walrasian mechanism (at least on the demand side). Second, there are *many* interim-efficient and individually rational allocations even in the large-numbers case (to see this, note that the left-hand side of condition (3), which weights all apple-growers equally and corresponds to surplus-maximization, can be rewritten with unequal weights, in which case it corresponds to some other interim-efficient allocation). One would have to argue that surplus-maximization has some special salience for agents to single it out. Of course, this is one role that institutions and traditions play —to select one equilibrium from among many.

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