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A Note on the Taxonomy of Goods

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COMPLETING OSTROM'S TABLE: A NOTE ON THE TAXONOMY OF GOODS

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Abstract

A framework is proposed to subsume public goods and common-pool resources, respectively, as specific cases of positive and negative externalities. A pure public good is a positive externality whose appropriable benefits are too small or too uncertain relative to the high private cost for anyone to produce it in any amount. The common-pool problem is a case where each agent's action imposes a negative externality on everyone else.

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COMPLETING OSTROM'S TABLE:
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Elinor Ostrom's well-known four-way classification of goods (Table 1) according to exclusiveness and subtractability, has become so established as to have found its way into the standard textbooks[1] e.g., in Mankiw [2012: 219].

Table 1. Ostrom's table

	Excludable	**Non-excludable**
Subtractable	Private goods	Common-pool
Non-subtractable	Club-goods	Public goods

Based on Ostrom and Ostrom [1977:12]

Useful as it is, however, this classification leaves no room for the concept of externalities in the usual sense, whether positive or negative. This fact prevents the table from being a comprehensive conceptual framework. As a result, externalities generally necessitate a separate discussion. Mankiw's [2012] popular introductory economics text, for example, devotes a separate chapter each for externalities and for public goods and common resources, introducing Table 1 only in discussing the latter.[2] Yet Mankiw [2012: 219] does suggest that public goods and common resources are "closely related to the study of externalities", and he gives examples of a public good—if privately provided—amounting to a positive externality, while an

[1] A form of Table 1 seems to have first appeared in Ostrom and Ostrom [1977:12]. Ostrom [2003] credits Samuelson [1953] with the idea of nonsubtractability and the idea of non-exclusion is attributed to Musgrave [1959] and Olson [1963].

[2] These are respectively Mankiw's chapters 10 (externalities) and 11 (public goods and common resources).

additional use of a common resource generates a negative externality. No clear statement is provided, however, of the exact relationship between externalities, on the one hand, and of public goods and common resources, on the other, nor indeed is it shown how externalities are to be incorporated in the equivalent of Table 1.

In what follows we propose a natural way to show that public goods (resp. common-pool resource problems) can be classified—and more importantly defined—as special cases of positive (resp. negative) externalities.

Public goods as positive externalities

The earliest clear description of an externality as a "divergence between social and private net product" is due to Pigou [1937: II.IX.§10]:

> Here the essence of the matter is that one person A, in the course of rendering some service, for which payment is made, to a second person B, incidentally also renders services or disservices to other persons (not producers of like services), of such a sort that payment cannot be exacted from the benefited parties or compensation enforced on behalf of the injured parties.

Pigou's description of positive externalities can be illustrated as follows. Let x be the amount of a good with non-excludable and non-rival benefits accruing to two individuals U and V, with respective payoff-functions u and v possessing the usual nonnegative and decreasing first derivatives. The good is producible or procured at a constant marginal cost c. Pigou's notion involves the following equilibrium for the emitting and benefiting parties:

$$u'(x) - c = 0,\ x > 0 \qquad (1)$$

$$v'(x) - c < 0,\ \forall x$$

If $x^0 > 0$ fulfils the first equality for U, while $x = 0$ for V, the equilibrium payoffs are nonetheless $u(x^0)$ and $v(x^0)$ owing to non-exclusion. That is, at marginal cost c, the private benefit to U is sufficient to induce him to provide it on his own account, although in an amount that is may be less than socially optimal. There is no incentive for V, however, to produce the good on his own. In this sense, V free rides passively on U.[3]

The socially efficient level of production however is well-known to require a level of $x = x^*$ that fulfils the following first-order condition:

$$u'(x^*) + v'(x^*) - c = 0, x^* > 0, \tag{2}$$

which, if $v'(x^*) > 0$, implies $x^* > x^0$ on previous assumptions. The amount $v'(x^*)$ is then typically understood as the level of public subsidy required to attain the socially efficient level of provision.

The preceding characterisation of a positive externality, however, readily turns into a pure public-good situation when one has the following:

$$u'(x) - c < 0, \forall x$$

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[3] Pigou's original examples of positive externalities involved such unilateral private provisions as lighthouses, private parks, outdoor residential lighting, and scientific research. Coase's [1974] famous rebuttal of the lighthouse as an example of a public good was directed more at Samuelson than at Pigou and Sidgewick since—as Coase [1974:360] himself acknowledged—the latter two authors were well aware that lighthouses could be and were in fact privately owned and operated as club goods. Pigou and Sidgewick were merely pointing to the possibility that apart from the members of the club, there could be other beneficiaries. They were therefore holding up the lighthouse as an example of a club good with externalities, rather than as a pure public good. Pigou's original example never involved an argument for lighthouses being necessarily publicly provided, although Samuelson unmistakably thought they needed to be.

$$v'(x) - c < 0, \forall x \qquad (3)$$

$$u'(x^*) + v'(x^*) - c = 0, x^* > 0.$$

It is clearly socially efficient for the good to be provided at the level x^* that solves the strict equality, but no positive level of private provision is feasible. It is also obvious that the condition for the socially efficient level of x in (2) is identical to that in (3). The above condition, therefore, characterises a pure public good as one that would not be provided at all based only on private interest and private action.

From this, one can conclude that in contrast to a pure public good, a positive externality yields private benefits to *some* persons that are sufficiently higher than the cost of providing the good so that those persons see fit to provide positive—though possibly still socially inadequate—amounts of that good. A pure public good, on the other hand, is a special case of positive externality where *no one's* private benefits exceed the private cost of producing the good. As a result, in a base scenario and without further assumptions, the good would not be provided at all in a private-action equilibrium. From this flows the result that only government provision financed by taxation can support the production of that good.

Other attempts to provide an explicit connection have proven to be non-intuitive and inaccurate. Cornes and Sandler (1986: 43, 270) assert, for example, that "pure public goods are a subclass of externalities", differing from the latter only in that the actions of others enter additively into an agent's utility function. In the notation used above, Cornes and Sandler regard an externality as a general case where one has $u(z, y)$ and $v(y, z)$, in which z and y are respectively the amounts of the self-provided goods by persons U and V. They propose to define a pure public good only if one can write $u(z + y)$ and $v(z + y)$, $z + y = x$, where z and y are, respectively, the amounts of x produced by persons U and V. This is clearly inadequate, however, since an equilibrium where $x^0 = z^0 > 0$, $y^0 = 0$, would still not represent a case of a pure public good in plain language. Indeed, such a situation is exactly what Pigou's examples sought to represent: private estate owners providing afforestation, house owners investing in street lighting, factory owners cleaning their chimney smoke, and scholars sharing their research findings [Pigou 1937: II. IX. §12]. In none of these would one say that a "public good" was being provided; rather one would say that a positive externality was being emitted.

Our definition, by contrast, requires no special assumptions regarding technology. Instead it proposes to differentiate between the two cases solely in terms of the *observed equilibria*, i.e., whether a good or activity that is nonrival and non-exclusive in consumption is or is not produced in positive amounts in a private-action equilibrium.

The common-pool problem as a case of negative externalities

The case of a negative externality, on the other hand, is the well-known one where a person's action adversely affects that of another without compensation. We can show that this is also what happens in a common pool-resource.

The canonical case of negative externality, again following Pigou, is a that of an activity x one-sidedly engaged in by U that adversely affects another activity y that is of interest to V. In the relevant passage, Pigou gives such examples as game-keeping resulting in lands being overrun, factories in residential areas, urban congestion, and public disorder caused by the sale of intoxicants, and curiously, the externality imposed on children's health by women doing factory work. These cases may be illustrated by writing the two parties' respective objective functions as

$$\max u(x) - cx, \text{ and } \max v(y\,|x) - ky \text{ with } v_x < 0,$$ [4]

where $v(y|\,x)$ captures the effect of U's action on V's interests. An interior solution (x^0, y^0), if it exists, fulfils the following:

$$u'(x^0) - c = 0,\ x^0 > 0 \qquad (4)$$

$$v'(y^0\,|x^0) - k = 0,\ y^0 > 0.$$

The efficient outcome, however, requires a consideration of the problem

$$\max u(x) + v(y|\,x) - cx - ky,$$

the interior solution (x^*, y^*) of which, if it exists, yields the pair jointly described by:

$$u'(x^*) + v_x(y^*|x^*) - c = 0,\ x^* > 0 \qquad (5)$$

$$v'(y^*\,|x^*) - k = 0,\ y^* > 0.$$

The first equation in (5), which can be written as

$$u'(x^*) = c - v_x(y^*\,|x^*), \qquad (6)$$

is the familiar condition requiring U to account for the negative externality on V generated by his action.

This is interpreted as equating the private marginal benefit of x^0 with its social marginal cost. Since u' is everywhere decreasing by assumption, and $-v_x(y^*\,|x^*) > 0$, the right-hand side of (6), is less than that of (4) and $x^* < x^0$, a familiar result.

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[4] Simple functional forms that can serve the purpose are $u(x) = ax - bx^2$, and $v(y|x) = dy - hy^2 + ex$. It is important that the determination of x by U is *external* to V's optimization process. That is, it is not an explicit part of V's decision; otherwise, the situation departs from the case of a pure externality and becomes a strategic game.

The common-resource problem can be described in similar terms. Let U and V be potential users of a resource characterised by non-exclusion. The only difference between this and the previous case is that now both U and V *mutually* generate externalities, with the payoffs to each depending on the actions of the other:

$$u(x\,|y) - cx \text{ and } v(y\,|x) - ky, \text{ with } u_y, v_x < 0. \tag{7}$$

The private-action equilibrium entails each agent maximising his payoff, oblivious of his action's impact on others. The interior solution can be characterised as

$$u_x'(x\,|y) - c = 0 \;\Rightarrow x^0 \tag{8}$$

$$v_y'(y\,|x) - k = 0 \;\Rightarrow y^0.$$

Here, it is important that U, in arriving at his private action x^0, does *not* need to anticipate or form a conjecture regarding the action of the other party (the same holding true for V obtaining his y^0). It is in this sense that the other party's action is truly *external* to his decision. Otherwise, the situation is transformed into a game of strategy, which then requires one to adopt a particular game-theoretic solution. Each party attains his private

optimum, since nonexclusion implies the other's action presents no physical hindrance to his choice.[5]

The well-known socially efficient solution, however, involves maximising $u(x\,|y) + v(y\,|x) - cx - ky$, with first-order conditions

$$u_x'(x\,|y) + v_x'(y\,|x) - c = 0, \tag{9}$$

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[5] Again, forms similar to those in previous note may make this pedagogically clearer, i.e., $u(x|\,y) = ax - bx^2 - gy$ and $v(y|x) = dy - hy^2 - ex$, where the first-order conditions for a maximum do not involve the actions of the other party.

$$u_y'(x\,|y) + v_y'(y\,|x) - k = 0,$$

allowing one to locate (x^*, y^*), where $x^* = x(y^*)$ and $y^*= y(x^*)$, and yielding the value of the objective function at an optimum:

$$u(x^*|y(x^*)) + v(y(x^*)\,|x^*) - cx^* - ky^*.$$

It is easily seen that the first condition in (9) can also be written as:

$$u_x'(x^0\,|y(x^0)) = c - v_x(y(x^0)\,|x^0) > 0. \qquad (10)$$

The above is to be contrasted with the inefficient private-action outcome described in (8).

More important, however, is the evident similarity between (10) and (6). Like the latter, (10) says that the inefficiency of the private-action equilibrium is really due to U's failure to take into account the negative effect of his action (or entry) on V. In short, U's action imposes a negative externality on V. Using the second equation in (9), it can be shown equally, of course, that V's action imposes a similar negative externality on U. There is no equivalent of this, however, in the simple unilateral negative externality described in (5).

This argument is easily generalised for any number of actors. Indeed, the existence of a large number of agents renders more plausible the presumption that an agent takes their actions as exogenous to his own decision. Large numbers raise the transactions costs and also prevent a recourse to a Coasean solution to externalities. The simple example, however, suffices to demonstrate how a common-resource problem can at bottom be understood as a case of negative externality. The basic similarity will be also noted in terms of the proposed institutional solutions. A common-resource problem—just like a negative externality—can be addressed either through unified ownership or a tax equivalent to – $v_x(y(x^*) \mid x^*)$.[6]

The above results make it possible to augment Ostrom's original table classifying goods by type as follows:

Table 2. Ostrom's table augmented

	Excludable	**Non-excludable**	
		One-sided	*Reciprocal*
Subtractable	Private goods	Negative externalities	Common-pool resources
Non-subtractable	Club goods	Positive externalities	Public goods

Conclusion

The preceding discussion can be briefly summarised as follows: *First*, all externalities in principle involve the problem of non-exclusion. Positive externalities are instances of non-exclusive and non-rival activities, while negative externalities are non-exclusive and rival. *Second*, a pure public good is a special case of a positive externality where physical production costs are so high, or information is so impacted, as to dissuade anyone from privately providing any level of the positive externality. *Third*, a common-pool resource is simply a special form of negative externality where everyone's action imposes a negative externality on everyone else.

[6] Another important difference is that—unlike the case of a ons-sided externality—it is difficult to appeal to the so-called Coase theorem in the case of a common-pool problem owing to the typically large number of actors involved, which tends to raise transactions costs.

REFERENCES

Coase, R. [1974] "The lighthouse in economics", *Journal of Law and Economics* 17(2): 357-376

Cornes, R. and T. Sandler [1986] *Theory of externalities, public goods and club goods*. Cambridge University Press.

Mankiw, N. [2012] *Principles of economics,* 6. edn. South-Western, Cengage Learning.

Musgrave, R. [1959] *The theory of public finance*. New York: McGraw-Hill.

Olson, M. [1963] *The logic of collective action*. Cambridge, Mass.: Harvard University Press.

Ostrom. E. [2003] "How different types of goods and property rights jointly affect collective action" *Journal of Theoretical Politics* **15**(3): 239-270.

Ostrom, V. and E. Ostrom [1977] "Public goods and public choices" in: E. S. Savas (ed.), *Alternatives for delivering public services: toward improved performance.* Boulder, Colorado: Westview Press. 7–49.

Pigou, A. [1937(1920)] *The economics of welfare* (Fourth edition). London: MacMillan and Co.

Samuelson, P. [1953] "The pure theory of public expenditure", *Review of Economics and Statistics* **53** (November): 387-389.