A Voting Approach to Externality Problems

David A. Anderson

Pre-Publication Draft

Published as:
Anderson, David A. (2011) "A Voting Approach to Externality Problems," *Journal of Economic and Social Policy*: Vol. 14: Iss. 1, Article 4.

I. Introduction

Imperfect information confounds policy decisions involving external costs and benefits. When the burden of externalities is not publicly known, even a benevolent government that is free of transaction costs cannot ascertain efficient outcomes. The existing literature offers theoretically pure remedies that bring private information into play, but with limited applicability. This research identifies several common scenarios in which a voting solution yields efficient outcomes in theory and in practice.

Voting allows democracies to mete out decisions in the face of conflicting perspectives. Majority rule caters to the desires of the greatest numbers; unanimity adds gratifying consensus. It is clear from the voting literature that neither majority-rule nor unanimity-rule voting assures Pareto efficiency.[1] However, in the conception of policies to address the problem of social cost, this article demonstrates that straightforward voting mechanisms can yield efficient choices even when alternative solutions fail. This article is the first to identify a broad class of common externality problems for which voting forces individuals to internalize the effects of their own behavior and vote for the most efficient policy from a societal standpoint.

Externality problems persists[2] despite theoretical solutions posited by myriad scholars. Given the complex array of external costs and benefits in any economy,

---

[1] For a recent example, see Dougherty and Edwards (2005).
[2] For example, Armour et al. (2005) estimate that 38,112 deaths each year are attributable to secondhand smoke, and Abt Associates, Inc. (2004) estimate that particulate matter emissions from power plants cause 24,000 premature deaths annually. It is not the existence of externalities that indicates a problem, for it is routine for the efficient level of an externality to be positive.

it is appropriate to consider diverse, situation-specific remedies. In regard to market goods and services, Pigou (1932) described taxes and subsidies as tools with which to impose external costs and benefits onto decision makers. Pigouvian solutions can be efficient when policymakers have the requisite information for marginal analysis. Even then, however, tax and subsidy solutions can obscure improved opportunities for efficiency, such as an opportunity to move neighbors away from a point source of concentrated pollution with greater efficiency than taxing that source. Taxes and subsidies can also be redundant and lead to misallocations of resources if overlapping solutions such as litigation, benevolence, regulation, and risk burdens are in place (Viscusi, 1991, p. 129).

Coase (1960) described ways in which private bargaining could yield efficient decisions involving externalities, given established property rights and negligible transaction costs. Baumol (1972) stressed the often-prohibitive transaction costs associated with negotiations among large numbers of affected parties, inquiring, for example, "where have we seen automobile drivers pay one another to cut down their exhaust?" (p. 321). In more recent analysis, Anderlini and Felli (2006) and others demonstrate that common transaction costs can foil the efficiency of Coasian bargaining.

Hardin (1968) explained how private property rights can place the otherwise external costs of open-access land use onto property owners. The solution of privatization is embraced by Austrian economists among others.[3] Block (1998) argues that virtually any natural resource can be privatized in order to eliminate externality problems. However, it is not at this point feasible, nor clearly desirable, to privatize every open-access resource. Flowing water and air, the primary conduits for pollution externalities, are particularly difficult to track and privatize.

Each of these celebrated solutions is simple and intuitive when applied to the classic scenario of splitting the check, as is the voting solution.[4] For illustrative purposes, suppose ten individuals with similar tastes purchase glasses of wine that cost $10 each, and divide the cost evenly among themselves. As in the case of carbon dioxide emissions and other uniformly distributed pollution, each individual faces a private marginal cost equal to the social marginal cost divided by the number of participants, in this case $10/10 = $1, when deciding on a

---

Rather, it is the concurrent absence of effective solutions to the market failure caused by externalities in these contexts that suggests that the mortality levels may not be efficient.

[3] For a recent example see Libecap (2009).

[4] Recent discussions of the splitting-the-check problem include Frank and Bernanke (2007), p. 460, and Anderson (2007), p. 75.

purchase that would impose a cost of \$10 on the group. The external payment of a portion of the cost leads to excessive consumption, for each individual will purchase wine until the marginal benefit no longer exceeds the private marginal cost of \$1, rather than stopping at the efficient point at which the marginal benefit no longer exceeds the social marginal cost of \$10.

The Pigouvian solution would be to impose a tax of \$9 per glass, for this would bring the private marginal cost of wine up to equal the social marginal cost. Individuals would thereby internalize the full cost of purchasing another glass. The Coasian solution would be for the individuals to offer each other bribes of up to \$9 (collectively) not to make additional wine purchases, again bringing the private marginal cost up to \$10. The Hardin/Austrian solution would have each individual internalize the cost of wine by privatizing the decision, i.e., by having the individuals pay for their own wine purchases rather than splitting the check. Each of these approaches could yield the efficient solution if proper implementation were not prohibited by the limitations already explained.

An alternative solution would be for the group to vote on whether to purchase another round. A successful vote of "yes" would result in the purchase of ten glasses and impose a cost of \$100/10 = \$10 on each person. This leads to the efficient outcome by eliciting unanimous "yes" votes if and only if the individuals value another beverage at least as much as the full cost of that beverage. There is no need for artificial incentives or information sharing beyond a tally of votes. In this and other contexts, the attractive influence-spreading mechanism of voting is an unacknowledged source of Pareto efficiency.

With roots in the seminal work of Buchanan and Tullock (1962) among others, common themes in the voting literature include analyses of voting efficiency and stability among voters with heterogeneous, fully internalized payoffs.[5] It is clear that majority-rule outcomes can be inefficient with such payoffs. For example, if three individuals would receive payoffs of 1, 1, and -3, respectively, from a particular motion, the majority-rule outcome would be in favor of the motion although it creates a net loss. In an article on the possibility of rational outcomes from democratic procedures, van Mill (1996) writes, "the conclusion of social-choice theory is that majority rule is inherently irrational and unstable in its outcomes." In contrast, the present study examines a set of scenarios in which the payoffs are partially or completely external to the voters and identifies conditions for efficient outcomes with useful applications.

[5] For a recent example see Battaglini, Morton, and Palfrey (2007).

In an empirical study of common-pool resources, Walker et al. (2000) found that voting solutions lead to relatively efficient outcomes. However, their study differed substantially from the present study because the role of voting in the Walker et al. study was one of information signaling rather than of triggering the internalization of externalities.

As an alternative to voting in the context of public goods, Clarke (1980) developed demand-revelation theory to address market failure as the result of free riding. Mueller (2003) explains that demand revelation can determine the advisability of collective action and assist with the equitable distribution of net benefits. Although demand-revelation procedures could be applied to externality problems, the need for individual-specific information on willingness to pay, among other inherent complexities, means that these solutions work well in theory but have few practical applications.

The voting approach to social cost complements other solutions by working in situations in which they do not. Most notably, voting applications are not strictly for market goods and services as are Pigouvian solutions, they do not necessitate the confrontations of Coasian bargaining, they do not require universal privatization as with Austrian solutions, and they do not require public knowledge of individual willingness-to-pay levels as do demand-revelation procedures.

Section II of this paper introduces the model and presents three formal propositions. Section III discusses broader applications of the voting solution. Section IV concludes the paper.

II. The Model and Propositions

The voting approach to social cost applies to an extensive class of environmental and development activities including water extraction or diversion, air and water pollution, overfishing, brownfield development, clean-up efforts, and zoning. Let us consider the model and propositions in the context of water pollution. As in many developing areas, suppose a community of n households is situated around a lake into which waste is deposited via a "straight pipe."[6] Assume that in each

[6] A straight pipe is a direct conduit from a pollution source to a waterway, with no associated systems of filtration or processing. Note that although it may be difficult to monitor the use of straight pipes, it is not difficult to monitor the use of septic systems. Thus, a policy mandating septic systems would be enforceable. Sewage dumping from private homes and houseboats is a common problem on small lakes. For example, the Kentucky Division of Water and the Kentucky Department for Health Services warn swimmers to avoid portions of the upper Cumberland River, the North Fork of the Kentucky River and the Licking River due to high levels of fecal coliform bacteria (see www.enquirer.com/editions/2001/05/29/loc_state_cracks_down_on.html). On larger

home lives one voting resident and that each resident has the option to purchase a septic system that eliminates the need for releases into the lake. Let c represent the cost per home of a septic system and let e represent the discounted present value of damage from each home's emissions in the absence of a septic system.

As is common in related pollution models,[7] assume the effect of emissions on water quality and associated recreation, consumption, and irrigation is spread uniformly throughout the lake, and each resident internalizes a share e/n of the damage. The rational private criterion is to purchase a septic system if $c < e/n$, whereas the efficient solution from a societal standpoint is to abate emissions if $c < e$.

It would be possible for a governing body such as a neighborhood association or municipality to mandate a septic system for each home. However, without full information on a proposal's costs and benefits to society, even a benevolent policymaker would be unprepared to make efficient decisions. In contemplating this requirement, a community leader could also face inefficient incentives not unlike those of the private decision maker. As agents for the voters, officials face the principal-agent problems of opportunism and corruption. For example, Riker and Brams (1973) and Uslander and Davis (1975) demonstrate that in voting by public officials, vote trading or "logrolling" can lead to suboptimal outcomes.

Let us consider three propositions in the context of environmental policy decisions. The initial assumption of homogeneous polluters is relaxed in subsequent propositions. In each case the contemplated policy measure entails the collective abatement of a pollutant as determined by either majority-rule or unanimity-rule voting. Section III describes real-world applications of each proposition.

Proposition 1: If individuals are identical and fully informed, voting among any number of individuals on a policy to collectively abate a uniformly distributed pollutant will yield efficient policy decisions.

---

lakes there are analogous problems with sewage dumping by municipalities (see www.house.gov/schakowsky/press2004a/pr6_15_2004lake.html).

[7] See, for example, Lai and Hu (2005) and Jones and Manuelli (2001).

Under these conditions each resident internalizes *e/n* of his or her own emissions damages and receives $[(n\text{-}1)e]/n$ of the damage from other homes. The total damages felt by each resident are thus

$$\frac{e}{n} + (n-1)\frac{e}{n} = e, \qquad [1]$$

and each resident has the incentive to vote for mandated septic systems if cost *c* is less than the value of damages received by each resident. Because each resident will vote efficiently, it does not matter how many people vote—the efficient outcome is independent of voter turnout and will result from majority-rule or unanimity-rule voting.

Proposition 2: If fully informed individuals are heterogeneous in regard to the level of damages they cause, votes among any number of individuals on the collective abatement of a uniformly distributed pollutant will yield efficient policy decisions.

Suppose there are two levels of emissions, high (e_h) and low (e_l), and that *x* homes emit at the high level and *n*-*x* homes emit at the low level. Residents in homes emitting e_h internalize e_h/n and receive $[(x\text{-}1)e_h + (n\text{-}x)e_l]/n$ of the damage from other homes. The total damage received by each high-emitting home is thus

$$\frac{e_h}{n} + \frac{(x-1)e_h + (n-x)e_l}{n} = \frac{xe_h + (n-x)e_l}{n} = \bar{e}. \qquad [2]$$

Residents from high-emitting homes will vote for a septic system requirement if the cost is less than the average level of emissions, $\bar{e}$. The policy measure will pass if $c < \bar{e}$, or equivalently, if total costs (*nc*) are below total emissions damages ($n\bar{e}$).

The analogous equation for low-emitting homes also shows that each resident experiences the average level of damages and will vote for the new measure if and only if it is efficient:

$$\frac{e_l}{n} + \frac{(x)e_h + (n-x-1)e_l}{n} = \frac{xe_h + (n-x)e_l}{n} = \bar{e}. \qquad [3]$$

Again, because each resident will vote efficiently, voter turnout is not an issue and efficiency will be achieved with either majority-rule or unanimity-rule voting. This outcome can be generalized to any number of emission levels.

Proposition 3: If individuals are fully informed and create the same or different levels of a uniformly distributed pollutant, and if a homogeneous amount of the damage created by each individual is completely external, a vote among affected parties on collective abatement will yield the efficient solution.

Allow *e* to again represent the variable amount of pollution emitted by each home and let ε represent the amount of completely external damage per home. The damage received by each resident is the sum of: (a) the internalized share of the damage he or she creates; (b) the resident's share of the uniformly distributed damage created by others; and (c) the resident's share of the completely external damage created by others:

$$\frac{e}{n}+\frac{(n-1)e}{n}+\frac{(n-1)\varepsilon}{n-1}=e+\varepsilon\ . \qquad [4]$$

If homes are heterogeneous in the level of uniformly distributed pollution they emit, as demonstrated under Proposition 2, each resident will internalize the average level of uniformly distributed pollution, $\bar{e}$. Each resident will also internalize the full per-capita external component as demonstrated in Equation [4]. Thus, whether or not the shared component of pollution is homogeneous, each resident will fully internalize the average level of both types of damage and clean-up measures will receive the unanimous vote if $c < \bar{e} + \varepsilon$.

Corollary: If individuals are fully informed and emit a homogeneous level of a uniformly distributed pollutant that is completely external, a vote among affected parties will yield the efficient solution.

This is a special case of Proposition 3 in which $e = 0$. Equation [4] thus becomes

$$0+\frac{(n-1)\varepsilon}{n-1}=\varepsilon\ , \qquad [5]$$

and the voting solution will be efficient.

III. Discussion

Common scenarios exemplify the conditions described in the propositions above. Proposition 1 stipulates equal contributions of uniformly distributed pollution. In the context of overfishing, this is analogous to the assumptions in the classic Gordon (1954) fisheries model in which fishers are homogeneous and share equally in the social cost of additional fishing effort. Under these typical assumptions, votes to determine fishing or hunting seasons, catch/kill limits, and policies on mass-catch equipment would yield efficient outcomes. If drivers contribute comparable amounts of particulate matter and related pollutants to the local air, votes on the adoption of new auto emissions technology[8] would be efficient to the extent that voters drive. If residents place similar burdens on regional landfills, votes on mandatory recycling programs would yield efficient outcomes that are not achieved when individuals decide independently whether or not to recycle.

Proposition 2 allows for heterogeneous emissions levels. This would be the case, for example, when contemplating smoking policies. There is a wide variation in the level of smoking among individuals, but secondhand smoke is relatively evenly distributed within a given indoor smoking area. Thus, votes to determine whether smoking should be allowed in particular facilities would yield efficient decisions among informed individuals.

As with policies to control other sources of social cost, legal reform to limit the external cost of litigation remedies is prone to inefficiency. Applying the model above to personal-injury litigation, for example, the cost term c in the model would represent the cost of internalizing (e.g., with private insurance) the burden of personal injuries, as from automobile accidents. The social cost e would be the expected net value of the litigation burden created by each member of a society in which litigation is employed as a remedy for personal injuries.[9] Some drivers are more reckless than others (e varies, as in Proposition 2), yet the burden is distributed with relative uniformity because the probability of becoming a victim is similar for most individuals.[10] Thus, a vote among informed individuals on the availability of litigation remedies or the existence of caps on damage awards could be efficient.

Proposition 3 stipulates a homogeneous level of pollution that is completely external. This could apply to the consideration of a "bottle bill" that places a deposit on beverage containers. Without such a bill, containers are more or less uniformly distributed along roadways and waterways. The use of containers may

---

[8] Examples include Honda Motor Co.'s new "ultraclean" diesel system. See www.greencar.com/features/honda-diesel/.

[9] Because settlements and jury awards represent transfers rather than net losses to society, the net burden comes from the disutility of uncertain outcomes and from expenditures on litigation and litigation avoidance that could otherwise be reallocated to achieve a net gain in utility.

[10] An exception would be potential victims who themselves drive recklessly. However, their contribution to the likelihood of injury would be internalized because in the common standard that contributory negligence results in cost sharing by the victim.

be similar across individuals, but it is unlikely that any individual would pollute his or her personal property with containers, making the pollution entirely external to the particular polluter. A vote among well informed citizens on a bottle bill could thus be expected to yield an efficient outcome.

The propositions in this paper rely on the standard assumption of rational, informed voters. Wittman (1989) argues that the amount of information held by voters has been underestimated. Bell, Huber, and Viscusi (2009) find that the median voter values water quality more than non-voters. In any event, a greater reliance on voting mechanisms would motivate the dissemination of information and could serve to elevate the level of knowledge and discourse about issues of social cost.

IV. Conclusions

Of the several well defined approaches to the problem of social cost, in practice, none is complete or compelling as a remedy for the tragedy of the commons among other sources of market failure. By giving each individual a hand in determining the behavior of every individual, the voting mechanism can achieve efficient outcomes for society while its members act selfishly in their own self interest. The propositions in this article apply to a broad array of issues including air, water, and noise pollution, overfishing, legal reform, fuel economy standards, smoking bans, bottle bills, recycling programs, community mosquito-control measures, mandated insurance coverage, and zoning. To the extent that related policy decisions are currently determined by public ballot, this article suggests that the resulting decisions are efficient under the outlined conditions. For those decisions involving social costs made with scant knowledge of external costs and benefits, efficiency improvements could be achieved by adopting the proposed mechanism with which externalities are effectively internalized. Further inquiry could consider a relaxation of the full-information assumption.

V. References

Anderlini, L., Felli, L., 2006, “Transaction Costs and the Robustness of the Coase Theorem,” *Economic Journal*, 116, 223-245.

Anderson, D. A., 2007, *Economics by Example*, New York: Worth Publishers.

Armour, B. S., Woollery, T., Malarcher, A., Pechacek, T. F., and Husten, C., 2005, “Annual Smoking-Attributable Mortality, Years of Potential Life Lost, and Productivity Losses—United States, 1997-2001,” *CDC Morbidity and Mortality Weekly Report*, 54:25, 625-628.

Abt Associates, 2004, *Power Plant Emissions: Particulate Matter-Related Health Damages and the Benefits of Alternative Emission Reduction Scenarios*, Available online at: www.catf.us/publications/index.php.

Battaglini, M., Morton, R., and Palfrey, T. R., 2007, "Efficiency, Equity and Timing in Voting Mechanisms," *American Political Science Review*, 101:3, 409-424.

Bell, J., Huber, J., Viscusi, W. K., 2009, "Voter-Weighted Environmental Preferences," *Journal of Policy Analysis and Management*, 28:4, 655-671.

Baumol, W., 1972, "On Taxation and the Control of Externalities," *American Economic Review*, 62:3, 307-322.

Block, W., 1998, "Environmentalism and Economic Freedom: The Case for Private Property Rights," *Journal of Business Ethics*, 17, 1887-1899.

Buchanan, J. M., Tullock, G., 1962, *The Calculus of Consent: Logical Foundations of Constitutional Democracy*, Ann Arbor: University of Michigan Press.

Clarke, E. H., 1980, *Demand Revelation and the Provision of Public Goods*, Cambridge, Mass.: Harper & Rowe, Ballinger.

Coase, R.H., 1960, "The Problem of Social Cost," *Journal of Law and Economics*, 3, 1-44.

Dougherty, K. L., Edward, J., 2005, "A Nonequilibrium Analysis of Unanimity Rule, Majority Rule, and Pareto," *Economic Inquiry*, 43:4, 855-864.

Frank, R. H., Bernanke, B. S., 2007, *Principles of Economics 3e*, New York: McGraw-Hill/Irwin.

Hardin, G., 1968, "The Tragedy of the Commons," *Science*, 162, 1243-1248.

Gordon, H., 1954, "The Economic Theory of a Common-Property Resource: The Fishery," *Journal of Political Economy*, 62, 124–142.

Jones, L., Manuelli, R. 2001, "Endogenous Policy Choice: The Case of Pollution and Growth," *Review of Economic Dynamics*, 4:2, 369-405.

Lai, Y.-B., Hu, C.-H., 2005, "Trade Liberalization and Transboundary Pollution," *Environmental Economics and Policy Studies*, 7: 1, 1-14.

Libecap, G. D., 2009, "The Tragedy of the Commons: Property Rights and Markets as Solutions to Resource and Environmental Problems," *Australian Journal of Agricultural and Resource Economics*, 53:1, 129-144.

Mueller, Dennis C., 2003, *Public Choice III*, New York: Cambridge University Press.

Pigou, A. C., 1932, *The Economics of Welfare*, London: Macmillan.

Riker, W. H., Brams, S. J., 1973, "The Paradox of Vote Trading," *American Political Science Review*, 67, 1235-1247.

Uslaner, E. M., Davis, J. R., 1975, "The Paradox of Vote Trading: Effects of Decision Rules and Voting Strategies on Externalities," *American Political Science Review*, 69:3, 929-942.

van Mill, D., 1996, "The Possibility of Rational Outcomes from Democratic Discourse and Procedures," *Journal of Politics*, 58:3, 734-752.

Viscusi, W. K. 1991, *Reforming Products Liability*, Cambridge: Harvard University Press.

Walker, J. M., Gardner, R., Herr, A., and Ostrom, E., 2000, "Collective Choice in the Commons: Experimental Results on Proposed Allocation Rules and Votes," *Economic Journal*, 110, 212-234.

Wittman, D., 1989, "Why Democracies Produce Efficient Results," *Journal of Political Economy*, 97:6, 1395-1424.