Incentives or Disincentives?

February 28, 2018

Abstract

If a policymaker wishes to encourage members of a population to take a socially beneficial action, should she reward those who take the desired behavior or punish those who do not? This paper develops a model that facilitates both utilitarian and majoritarian perspectives on the use of incentives and disincentives in public policy. An asymmetry arises between the two types of policy: incentives become more expensive to administer as they get larger because a higher share of the population takes the beneficial action and earns the reward; disincentives become less costly to administer as they get larger, however, because fewer people fail to take the desired action and earn the punishment. Policy domains that favor inducing high (resp. low) shares of the population to take a desired behavior thus also indirectly favor the use of disincentives (resp. incentives). Redistributive implications for members of the population only amplify this tendency.

Keywords: Rewards, punishments, subsidies, fines, redistribution, policy instruments

1 Introduction

In 2017, Congressional Republicans made numerous attempts to fulfill a seven-year promise to repeal the Affordable Care Act (ACA). Central to conservatives' complaints about the ACA was the individual mandate, which requires individuals to purchase health insurance or else pay a fine. It followed, then, that a key element of all of the Republican proposals was replacing the individual mandate with tax credits intended to subsidize the purchase of insurance. Certainly a number of other issues were on the table, including essential coverage standards, pre-existing conditions, and funding for Medicaid. The heart of the debate, though, was the question of whether government ought to incentivize the purchase of insurance or disincentivize the failure to insure oneself.[1]

The decision between using incentives or disincentives to achieve a given policy aim is hardly limited to healthcare. In the realm of environmental policy, government discourages polluting activities through taxes, while initiatives such as Cash for Clunkers reward the retirement of less efficient vehicles to subsidize the purchase of more efficient vehicles. National education policy has featured both disincentive- and incentive-based policies in recent years in the form of No Child Left Behind and Race to the Top, respectively (Howell 2004, Howell & Magazinnik 2017). The domain of agricultural and food policy abounds with examples: the Conservation Reserve Program incentivizes farmers to take land out of agricultural production (Wilde 2013),[2] the infamous "sugary drink taxes" are a disincentive for unhealthy consumption,[3] and in many cities individuals receive double the value of food stamps when they buy fruits and vegetables, a reward for healthy consumption choices.

Broadly, for a policymaker seeking to encourage members of a population to take a certain behavior, is it better to reward those who take the behavior with incentives, or punish those who do not with disincentives? The examples above illustrate that this is not merely a thought exercise. In practice, policymakers turn to both incentives and disincentives, even within a given policy domain, and often to achieve similar aims.

This paper uses a model to offer normative (specifically, utilitarian) and positive (majoritarian) perspectives on this question. The setting is kept as simple as possible while still emphasizing distinguishing features of a policymaking environment. Each member of a population will choose one of two actions, one of which

[1]See the Senate Republican Policy Committee's post from May 2, 2017, `https://www.rpc.senate.gov/policy-papers/the-american-health-care-act-of-2017`.

[2]`https://www.fsa.usda.gov/programs-and-services/conservation-programs/`, accessed January 2017.

[3]Neuman, William. Sept. 16, 2009. "Proposed Tax on Sugary Beverages Debated." *The New York Times*, accessed at `http://www.nytimes.com/2009/09/17/business/17soda.html`.

is more socially beneficial than the other. The propensity to choose this action – in the absence of any policy inducements – varies across members of the population. Two sets of questions follow. The first set of questions surrounds the conditions under which a utilitarian social planner would turn to incentives or disincentives to encourage the socially beneficial action. The second set of questions asks what policy a majority of the population would support given the redistributive implications, in terms of both the type of policy and whether it serves to encourage the socially beneficial action or the socially-harmful action. Comparing the majority-preferred policy benchmark to the utilitarian serves to characterize the way in which the policy outcome of a democratic process is likely to differ from the (utilitarian) optimal policy.

Throughout, the model assumes incentives and disincentives influence the behavior of members of the population identically. Adopting such a stark rational choice perspective challenges the model to disprove the null hypothesis that incentives and disincentives are simply two sides of the same enforcement coin. Most importantly, it enables the analysis to uncover an asymmetry between the two policies common to nearly all policymaking settings. Section 2 discusses the reasons for and implications of this approach in greater depth, as well as the way in which the paper's focus differs from and builds upon a number of related literatures. It is in this spirit, for instance, that the analysis focuses on pecuniary policies: fines and taxes on one hand, subsidies and financial rewards on the other.

In seeking to model incentives and disincentives symmetrically, it is essential that the various costs and benefits associated with a policy intervention accrue similarly under both types of policy. Section 3 specifies the utilitarian policymaker's considerations, namely, the external benefit, which rises in the share of the population taking the socially beneficial action; the loss in well-being incurred by inducing some members of the population taking their less preferred action, which accrues as the policy intervention grows larger; and the cost of administering an incentive or a disincentive, which increases in the share of the population to which a given policy is administered. The redistribution of revenue generated from fines and the financing of subsidies both occur through lump-sum transfers, with each member of the population receiving and contributing an equal share, respectively. A utilitarian social planner is unconcerned with transfers, net of the administrative costs. While the costs entailed in government intervention always deserve attention, the costs of administering policy interventions play an especially central role here.

Policies apply to populations, not single entities. The model captures this constraint by imposing that all those who take an incentivized behavior are entitled to any reward being offered and at the same level, while all those who do not may receive any punishment on the books, again at the same level. An important asymmetry follows when combined with the premise that the administrative cost associated with a given policy grows in the share of the population receiving that policy.

Increasing the size of an incentive induces a larger share of the population to take the desired action, which in turn increases the share of the population who must receive the reward, causing administrative costs to rise. Increasing the size of a punishment also induces a larger share of the population to take the desired action, but this reduces the share of the population who must receive the punishment, causing administrative costs to fall. As such, the administrative cost of disincentives (resp. incentives) falls (resp. rises) as a larger share of the population takes the desired action. In light of this asymmetry, both the type of policy (incentive or disincentive?) as well as the size of the intervention (how big is the reward/punishment, how much compliance does it induce?) are of interest.

Formally, inducing higher shares of the population to take the beneficial behavior and the use of disincentives (rather than incentives) are complements to one another. Section 4 explores the consequences of this complementarity for the type and size of intervention a utilitarian social planner would endorse. Comparative statics explore how these answers change in response to changes in the rate at which benefit accrues to society from its members taking the socially beneficial action, the distribution of preferences for taking the beneficial action across the population, and the costs of administering each type of policy intervention. Broadly, conditions that favor inducing high shares of the population to take the beneficial action indirectly favor the use of disincentives, and vice versa for incentives.

The analysis then turns to the political economy of incentives and disincentives. Section 5 addresses the majority preference. While transfers drop out of the utilitarian's maximization function, this is not true for a member of the population. A member of the population's utility under a given policy then depends upon the action the policy induces that member to take, the benefit to society produced under the policy, the redistributive benefits net of the redistributive costs, and the administrative cost which is a loss that cuts into redistribution of revenues and raises the amount taxpayers must finance. A preliminary result establishes that the most-preferred policy of a given member of the population will also be the most-preferred policy of all other members that choose the same action under the policy. This implies that the majority preference is identical to preferences of the member of the population with the median valuation for taking the beneficial action.

The complementarity between using disincentives (rather than incentives) and inducing higher shares of the population to take the beneficial action, grows even stronger in the context of the majority preference than it was under a utilitarian perspective. The larger the incentive or disincentive, the more likely the policy is to induce the median member of the population to take the desired behavior. Furthermore, if a member of the population takes the beneficial action, the redistributive implications lead her to prefer a larger policy intervention. A larger intervention, though, induces a larger share of the population to take the beneficial action, which in turn makes disincentives relatively more cost-effective than incentives. Further, neither the median voter nor any other member of the population internalizes the costs imposed on others from a given policy. Section 6 lays out this logic in greater detail, but the significance is that the median voter, and thus a majority of the population, will tend to prefer larger-than-optimal disincentives and smaller-than-optimal incentives.

Section 7 explores an extension in which policies may be targeted at a sub-population of interest. The rest of the population is neither confronted with the action nor eligible for incentives or disincentives, but revenue from fines is distributed across the entire population, and all members of the population must contribute to the financing of subsidies. This analysis asks which policy a member of this only-indirectly-affected, at-large population would prefer. A member of the population at-large receives the same utility under a disincentive policy as a member of the subpopulation of interest who takes the beneficial behavior and the same utility under an incentive policy as a member of the subpopulation of interest who takes the socially-harmful behavior. The tendency for the majority to prefer excessively large punishments and insufficiently large rewards then becomes the rule. Specifically, if the preferred policy entails a disincentive, it will induce more of the beneficial behavior than the social planner would prefer, and if the preferred policy uses incentives, it will induce less of the beneficial behavior than the social planner would prefer.

While a utilitarian policymaker would never seek to increase the share of the population choosing the less beneficial (more harmful) action, this need not be the case under the majority-preferred policy. Indeed, policies that encourage the harmful behavior, usually through a tax on the beneficial behavior, arise in the analysis of majority-preference as an example of insufficiently large incentive policies. The majority-preferred incentive for the desirable behavior may be so small as to be negative, actually constituting a fine or tax on the socially-beneficial behavior. The suggestion that policies may run counter to societal benefit is perhaps not so surprising. Of interest, however, is that policies encouraging and discouraging the beneficial behavior may have highly similar implications for the utility of median voter, despite their drastically different intentions. Section 8 concludes with a brief summary and directions in which this modeling framework might be expanded.

2 Representing Policy

> ...the only fair way to begin must be with the tenet that there is no basic or universal rationale for having a general predisposition toward one control mode or the other... Even on an abstract level, it would be useful to know how to identify a situation where employing one mode is relatively advantageous, other things being equal.
>
> Weitzman (1974)

Two principles receive priority in modeling the use of incentives and disincentives as policy instruments. The first, and as per Weitzman, is to set up the two types of policies to be as similar as possible.[4] Accordingly, members of the population will respond identically to incentives and disincentives. This entails setting aside behavioral effects in order to adopt a strictly rational choice approach.[5]

The second principle in constructing the model is to embody the core realities of policymaking. These two aims may at times be at odds with one another. When this occurs, the Weitzman critique takes precedent and dictates modeling incentives and disincentives under the same assumptions. For example, only pecuniary rewards and punishments receive attention, and wealth constraints do not limit the effectiveness of fines. Features of policymaking environments that receive prominent consideration in the model include the heterogeneous propensities across the population for choosing one behavior over another and the costliness of policy implementation. Specifically, costs are increasing in the share of the population to which a given policy must be administered.

Rational choice analyses of policymaking have traditionally, if implicitly, assumed incentive and disincentive policies are equivalent enforcement mechanisms.[6] Political scientists have instead focused on aspects of the policymaking process surrounding the choice of policy instrument. The large literature on bureaucracy has devoted significant attention to the decision of a political principal to delegate decisions, such as those over the policy instruments, to other actors within the government (Gailmard & Patty 2013). In general, the delegation literature is premised on a conflict between a politically-sensitive principal and a public service-motivated bureaucrat in the sense of Weber (1948) or Miller & Whitford (2016). Yet the way in which utilitarian and majoritarian perspectives may be at odds, especially with reference to the choice of policy instrument, remains opaque. Even when it comes to the implementation of policy decisions, as in Pressman & Wildavsky's (1984) landmark study, the focus is on the target of policies, rather than the choice of instrument with which to pursue a given target.[7] This paper provides an account of the source and nature of the conflict

[4]Weitzman wrote on price vs. quantity policies; both incentives and disincentives constitute variants of price policies. The difference between price and quantity policies in his analysis and follow-on papers hinges on uncertainty about the benefits and costs of regulation (Pizer 1997, Grodecka & Kuralbayeva 2015), while the model herein relies only on the heterogeneity of actors within a population.

[5]A sizable body of behavioral work has studied differences likely to arise in individual-level responses to positive and negative inducements (e.g., Kaplow & Shavell 2007, Benabou & Tirole 2011).

[6]The equivalence is reminiscent of the symmetry in assigning liability in accidents/externalities (Coase 1960, Calabresi & Melamed 1972, Miceli 2004, Posner 2005).

[7]Economists have focused on a variety of other aspects of the strategic environment surrounding regulation (Stigler 1971, Posner 1974, Peltzman 1989, Shleifer 2005).

that may emerge between governmental actors with more utilitarian or more majoritarian perspectives.

In contrast to the work that treats incentive and disincentive policies as entirely interchangeable, public administration and legal scholars exploring alternative approaches to regulation have explicitly weighed "punishment" against "persuasion" (see Gunningham (2012), Baldwin, Cave & Lodge (2012, ch. 7), Lodge & Wegrich (2012, pp. 76-80), and De Geest & Dari-Mattiacci (2013)). While they highlight a variety of potential asymmetries between the regulatory strategies of incentives and disincentives, it is the embrace of these dissimilarities from the outset that prevents this work from speaking to more fundamental, institutional differences. To serve as an effective counterpoint to the notion that incentives and disincentives constitute essentially the same enforcement technology, one must begin more agnostically, treating the two approaches identically.[8]

Distributive conflict animates the analysis below of the majority-preferred policy, though the conflict differs in its origin from much prior work on redistribution. The field of distributive politics often takes redistribution itself as the primary source of distributive conflict (Baron & Ferejohn 1989, Becker 1983, Becker 1985). To the extent that other policy domains appear, it is often as an entirely separate dimension from a policy of interest, as in the literature on vote buying (Snyder, Jr. 1991, Groseclose & Snyder, Jr. 1996, Dekel, Jackson & Wolinsky 2008, Dekel, Jackson & Wolinsky 2009). The distributive conflict featured here, however, arises in the course of forming policy in domains that are not redistributive in nature.

3 A Model of Incentives and Disincentives

The setting consists of a single period in which all members of a population choose $a \in \{0, 1\}$ exactly once. The population consists of a unit mass of individuals. Denote a member of the population by i, and denote i's *ex ante* valuation for taking the desired action by v^i (i.e., in the absence of any incentives or disincentives).[9] Let the valuations be distributed according to a continuously differentiable cdf $F(\cdot)$, with $\underline{v} \leq v^i \leq \overline{v}, \forall i$. Note that v^i may be negative, indicating a latent propensity to take $a = 0$, or positive, indicating that i would choose $a = 1$ without any further inducement. Indeed, assume $\underline{v} < 0 < \overline{v}$, such that there are *ex ante* compliers and non-compliers in the population.

[8]Public enforcement work biases towards the study of punishment (Polinsky & Shavell 2000), though Becker (1968) is an exception. Meanwhile, moral hazard models, e.g., Holmstrom (1979), tend to feature only one agent (Banks & Sundaram 1998, p. 299). As in Dal Bo, Dal Bo & Di Tella (2006), this means both types of policy may be used with only one deployed in equilibrium, making the choice of instrument less consequential than it is in the context of a population.

[9]This term captures the net benefit of taking $a = 1$ or $a = 0$. Setting $u^i(0) = 0$, then $\forall i, v^i = u^i(1)$.

When members of the population choose $a = 1$ instead of $a = 0$, it imparts social benefit (or, equivalently, reduces social harm). As such, a utilitarian policymaker (or "social planner") would only consider policies that encourage $a = 1$ or $a = 0$. In principle, however, a policy may encourage either $a = 1$ or $a = 0$, and indeed redistributive implications may lead to majority support for a policy of incentives for $a = 0$ or disincentives for $a = 1$. The social planner's optimal policy receives attention first, though, because it serves as a benchmark for the subsequent analyses and is interesting in its own right as a particular normative point of view. Further, the model considers only monetary incentives and disincentives, namely subsidies and taxes, though the analysis is amenable to other kinds of incentive and disincentive policies.[10]

A policymaker wishing to encourage citizens to take action $a = 1$ rather than $a = 0$ may reward those who take the beneficial action ($a = 1$), punish those who do not ($a = 0$), both, or neither. To capture the constraints of policymaking, assume that the policy cannot impose different levels of reward or punishment across the population. This requires that any individual in the population receiving a reward receives the same level of reward, and similarly for punishments.Suppose at first that all members of the population are subject to the policy. An extension below considers the presence of an "unaffected" subpopulation – members of the population not subject to a choice of $a \in \{0, 1\}$ or the corresponding rewards or punishments. Suppose further that the policymaker has full information, sidestepping issues of probabilistic enforcement.

Incentives, R, and disincentives, P, enter additively into the utility functions of individuals as perfect substitutes, so as to abstract from behavioral concerns.[11] Individuals choose $a = 1$ in the case of indifference. It follows immediately that i chooses $a = 1$ if and only if the utility she derives from doing so plus any rewards offered for choosing $a = 1$ is at least as large as the utility she receives from choosing $a = 0$ minus any threatened punishments, i.e., $v^i + R \geq -P$. The following result derives the share of the population choosing $a = 1$ given disincentives of size P and incentives of size R.

Fact 1. *A member of the population i chooses $a = 1$ iff $v^i \geq -R - P$. The share of the population choosing $a = 1$ is then $1 - F(-R - P)$, while the share of the population choosing $a = 0$ is $F(-R - P)$.*

Let the function $W : [0, 1] \to \mathbb{R}$ represent the global external benefit to society from a given share of the population choosing $a = 1$. Let $W(\cdot)$ be continuously differentiable, with $W' > 0$. It is assumed that members of a population do not impose heterogeneous external costs and/or benefits through their actions.

Total rewards are given by $R \cdot [1 - F(-R - P)]$, as the entire share of those choosing $a = 1$ must be given the reward, which is of size R. This represents an addition to the utility of those receiving the reward but must be financed through taxation. Total punishments equal $P \cdot F(-R - P)$, as the share of those choosing

[10] Taxes connote fines here, as in "carbon tax," where the tax is a penalty, not redistributive in purpose.

[11] Receiving R will always be contingent on $a = 1$, paying P will always be contingent on $a = 0$.

$a = 0$ must receive the punishment. This represents a subtraction from the utility of those receiving the punishment but is then redistributed to the population as a whole. Lump-sum transfers applied uniformly across the population accomplish both the disbursement of revenues from fines as well as the financing of subsidies, à la Meltzer & Richard (1981). All members of the population thus receive an equal share of revenues collected from fines and carry an equal burden in financing subsidies.

Such transfers, however, are not administered without costs. Let $C_p : [0, 1] \to \mathbb{R}$ and $C_r : [0, 1] \to \mathbb{R}$ be differentiable functions giving the administrative cost incurred to apply disincentives and incentives, respectively, to a given share of the population. As such, C_p takes as its argument the share of the population choosing $a = 0$, F, while C_r takes as its argument the share of the population choosing $a = 1$, $1 - F$. To capture the notion that the costs of administering a policy are increasing in the measure of individuals to whom the policy is applied (those receiving rewards and/or those receiving punishments), $C_p'(\cdot) > 0$ and $C_r'(\cdot) > 0$.Such costs are only incurred if the policy entails a nonzero amount of punishment or reward, such that $C_p(F(0)) = 0$ and $C_r(1-F(0)) = 0$. Note this assumption also implies that $\forall F \in (0, 1) \setminus F(0), C_p(F) > 0$ and $C_r(1 - F) > 0$. To allow the fixed costs to differ from one another, let $C_p(0) \geq 0$ and $C_r(0) \geq 0$, where strict inequalities at 0 imply some fixed cost.

The two types of policy share many costs in common. In many instances, most monitoring costs are incurred across the entire population and would be necessary for either type of policy. The functions the above represent assignment, collection, and disbursement costs specific to each type of policy and incurred only if that given type of policy is in use. Consider the only somewhat stylized case of a community official tasked with preventing residential food waste.[12] The official must stop at each house to verify food has not been disposed of with the trash that heads to the landfill instead of in designated compost bins. Under a disincentive scheme, the official must spend additional time at each house that does not comply to write tickets; the cost of this policy thus rises in non-compliance. Under an incentive scheme, the official must stop at each house that has properly composted its food waste to fill out a reward or subsidy (perhaps a voucher for the bins or for compostable bags); the cost of this policy thus rises in compliance.

In summary, given a fine of size P and a subsidy of size R, revenues from fines available for redistribution are given by $P \cdot F(-R - P) - C_p(F(-R - P))$, while the required financing for a subsidy is given by $R \cdot [1 - F(-R - P)] + C_r(1 - F(-R - P))$. Every member of the population receives/pays these quantities, which account for the deadweight administrative costs entailed in each type of policy. Similarly, societal benefit from the share of the population choosing $a = 1$, given by $W(1 - F(-R - P))$, accrues to all members

[12] Radil, Amy. January 26, 2015. "Tossing Out Food In The Trash? In Seattle, You'll Be Fined For That." *The Salt*. Accessed as of January 2018 at `https://www.npr.org/sections/thesalt/2015/01/26/381586856/tossing-out-food-in-the-trash-in-seattle-you-ll-be-fined-for-that`.

of the population, regardless of whether they choose the desired behavior. Each member of the $1-F(-R-P)$ share of the population choosing $a=1$ receives R and incurs v^i, their valuation for choosing $a=1$. Those in the $F(-R-P)$ of the population choosing $a=0$ pay P and do not incur their v^i, be it positive or negative.

4 The Utilitarian-Optimal Policy

A utilitarian social planner gives equal weight to the utility of all members. She takes into account any positive externalities from members of the population choosing $a=1$ and/or negative externalities from those choosing $a=0$ accruing to individuals. Transfers have no net effect on the social planner's utility. The amount collected is equal to the amount disbursed whether the policy entails a fine or a subsidy. She does wish to minimize the deadweight costs of administering policies, all things equal. Further, the optimal policy must consider the utility that members of the population derive from their chosen action.

The internalized effects of individuals' actions on their utility across the population are given by the "sum" of the valuations of all those who choosing $a=1$. As our population is a continuum, this is given by $\int_{-R-P}^{\overline{v}} vf(v)dv$, where $\{i|v^i \in [-R-P,0)\}$ constitutes the set of those choosing $a=1$ *ex post* that would not have chose $a=1$ *ex ante*, without the inducement of any incentives or disincentives. Recall that v^i accounts for the benefits and costs of choosing $a=1$ to members of the population. As such, foregone utility or profit, or the cost of adopting a new technology, would be included in v^i. This quantity is decreasing in compliance, exerting downward pressure on the social planner's utility as more individuals switch from their *ex ante* preferred choice of behavior.

The social planner thus faces the following problem:

$$\max_{(P,R)\in\mathbb{R}^2_+} W(1-F(-R-P)) + \int_{-R-P}^{\overline{v}} vf(v)dv - \mathbb{I}_{P>0}\cdot C_p(F(-R-P)) - \mathbb{I}_{R>0}\cdot C_r(1-F(-R-P)), \quad (1)$$

subject to the constraint that this be greater than social welfare under the status quo, which is given by $W(1-F(0)) + \int_0^{\overline{v}} vf(v)dv$. Lemma 1 establishes that the policymaker will use only punishments or only rewards, if she intervenes at all. Proofs may be found in the Appendix.

Lemma 1. *It is never optimal to use strictly positive levels of both punishments and rewards.*

Recall that higher shares of the population choosing $a=1$ increase the administrative cost of rewards but lower the administrative costs of punishment policies. It follows then that there exists a threshold share of the population choosing $a=1$ above which punishment policies are cheaper and below which reward policies are cheaper. When indifferent, the policymaker would still never want to use both types of policy to induce that share of the population to choose $a=1$, as this would double up on the costs.

This result also highlights an important distinction between policymaking for a population and contracting for individuals. Even if a contract for a single agent featured incentives and disincentives, only one of these policies would be deployed, as the individual would either comply or not. Policies applied to a population will almost always result in compliers and non-compliers, such that under incentives and disincentives, both types of policies must be deployed.

The problem may now be stated as follows: determine the optimal size of reward, R^*, if restricted to only use rewards; determine the optimal size of punishment, P^*, if restricted to only use punishments; having found the optimal size of each type of policy, compare social welfare under P^* and R^* to find the optimal type (and size) of policy.

Results from the theory of monotone comparative statics help characterize the social planner's most preferred policy (Ashworth & Bueno de Mesquita 2006). To facilitate this approach, the type of policy is taken to be one choice variable, and the share of the population choosing $a = 1$ *ex post* is taken to be the other.[13] The choice over the type of policy compares the attractiveness of using punishments to the attractiveness of using rewards to induce a given share of the population to choose $a = 1$. The choice over the *ex post* share of the population choosing the socially beneficial action holds the type of policy fixed. The share of the population choosing $a = 1$ is a more meaningful measure of the "size" of a policy intervention than the value of P or R that induces that share of compliance. The decision to deploy a policy intervention or to remain at the status quo share of the population choosing $a = 1$ (when $P, R = 0$) is a subsequent decision in which the policymaker's utility under the optimal policy intervention (defined below) is compared to her utility under the status quo.

Definition 1 (Optimal Policy Intervention)**.** *The utilitarian policymaker's most-preferred policy intervention, characterized by an optimal share of the population choosing* $a = 1$ *and an optimal type of policy that together imply* $P^* > 0$ *or* $R^* > 0$.

The ultimate goal is to understand how the optimal choice of type and size of policy change as a function of changes in the exogenously given elements of the model. In a problem with two choice (i.e., endogenous) variables, the first step is to characterize the relationship between the two. The next lemma establishes that the *ex post* share of the population choosing $a = 1$ and the use of disincentives (as opposed to incentives) are complementary to one another. This is a direct result of the asymmetric way in which administrative costs accrue under incentive and disincentive policies.[14]

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[13]The equivalence of this approach is established, and the approach fully explicated, in Appendix A.1.

[14]Equation 5 and the surrounding discussion in Appendix A.1 suffice as a proof of the assertion.

Lemma 2. *An increase in the share of the population choosing $a = 1$ ex post (given by $1 - F$), is more attractive under the use of disincentives than under the use of incentives. Equivalently, the use of disincentives is increasingly attractive relative to the use of incentives as the share choosing $a = 1$ increases.*

Any exogenous change which leads to an increase (resp. decrease) in the optimal value of at least one of the choice variables will indirectly lead to an increase (resp. decrease) in the other. Noting that all increases/decreases are weak and ordering the choices of policy as $p > r$, we may adapt the preceding statement as follows. An exogenous change that increased the optimal share choosing $a = 1$ would make the use of punishments increasingly attractive relative to the use of rewards (though rewards may still be the optimal policy). An exogenous change that made punishments more attractive relative to rewards would indirectly lead to (a weak) increase in the optimal share of the population choosing $a = 1$.

The methods outlined ensure that indirect effects occurring among the choice variables reenforce the direct effect of an exogenous variable on the optimal policy. The crucial condition is complementarity between the parameter and both of the (complementary) choice variables. Only if a change in an exogenous variable leads to an increase in one choice variable but a decrease in the other will it be impossible to characterize the overall effect of a change in the variable on the optimal policy. The implication of such a "non-result" is that a comparative static derived from a given choice of functional form would not be robust to the choice of functional forms from among those that satisfy the broad conditions stated above.

The exogenous elements of the model are the functions $W(\cdot)$, $F(\cdot)$, $C_p(\cdot)$, and $C_r(\cdot)$. Proposition 1 appears in three parts to facilitate the exposition and explanation of the result for each parameter.[15] The proposition makes clear that complementarity between the exogenous element and both of the choice variables exists for some of the parameters but not all.

Proposition 1 (a)**.** *As the added value to society from an increase in the share of the population choosing $a = 1$ rather than $a = 0$ increases at all levels: the share choosing $a = 1$ in the optimal policy intervention increases; this indirectly makes the use of disincentives increasingly attractive relative to the use of incentives; further the optimal policy intervention becomes more attractive relative to the status quo.*

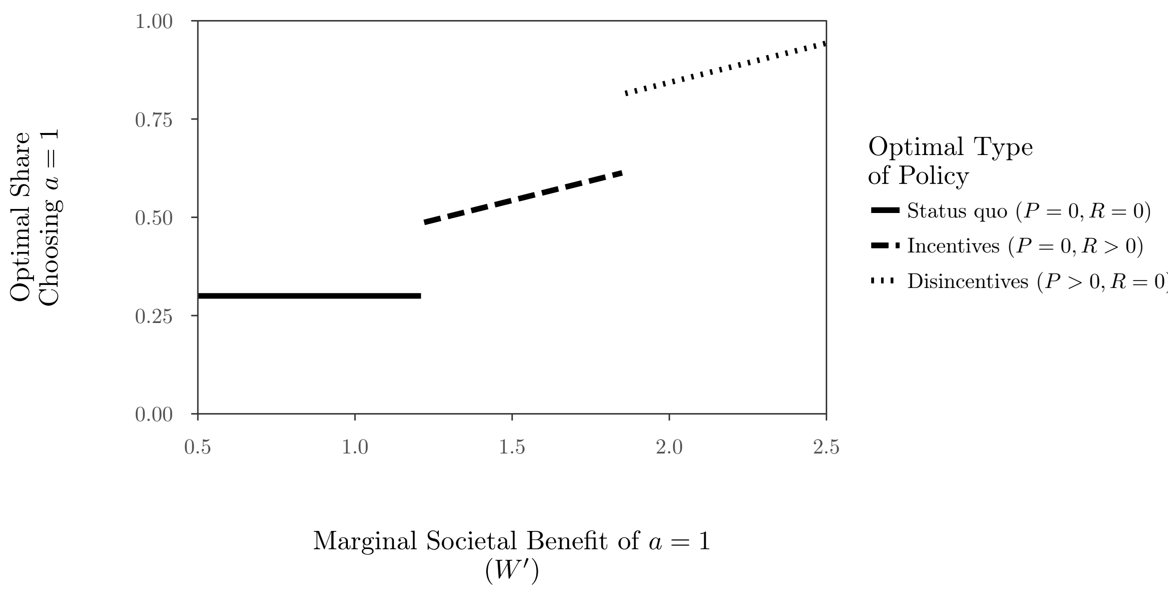
Part (a) of the proposition regards the externality at the heart of the social planner's problem. Recall that $W(\cdot)$ denotes either the societal benefit that accrues from a share of the population choosing $a = 1$ and/or the social cost from members of the population choosing $a = 0$. Increasing the added benefit from a larger share choosing $a = 1$ (for all $1 - F \in [0, 1]$) leads the social planner to want higher shares choosing $a = 1$ *ex post*. Even though there is no direct effect on the optimal type of policy, because of the complementarity between higher shares choosing $a = 1$ and the use of punishments rather than rewards, using disincentives

[15]Each part follows immediately from a more formal, corresponding statement given in Appendix A.2.

grows more attractive relative to using incentives. Finally, while increasing the benefit from a larger share choosing $a = 1$ increases the social planner's utility from the status quo, it increases the social planner's utility from the optimal policy intervention by at least as much. Policy interventions become more attractive as the added benefit from inducing more of the population to choose $a = 1$ increases.

Figure 1 depicts the comparative statics from part (a). As the marginal societal benefit from more of the population choosing $a = 1$ increases (at all levels), the optimal share choosing $a = 1$ is weakly increasing. Accordingly, the optimal type of policy moves from rewards to punishments. Further, once a policy intervention is optimal (vis-à-vis the status quo), policy intervention remains optimal as the marginal societal benefit of higher shares choosing $a = 1$ continues to increase.

Figure 1: The effect of increasing the marginal benefit to society of the share of the population choosing $a = 1$ on the utilitarian most-preferred share of the population choosing $a = 1$ and type of policy



Notes: The horizontal axis tracks increases in W', the marginal societal benefit, which is equal to g when societal benefit is given by $g \cdot [1 - F(-R - P)]$ (the functional form underlying the figure).

Consider the rewards in the form of monopolistic market power that are granted to patent and copyright holders. When inducing innovation of any given product or even artistic creation, most benefit accrues at low levels of "compliance" but levels off at higher levels of compliance. This suggests that rewards are likely to be optimal. The seeming absurdity of the notion that government might penalize people for not innovating is in fact a reflection of the inefficiency of punishing a large segment of the population in order to spur innovation by those with the highest *ex ante* valuation for innovating (likely those best positioned to do so). For actions in which the order and well-functioning of society depend on nearly full compliance (e.g., safe driving, respecting property rights, not committing violent acts), achieving small levels of non-compliance with a (possibly large) punishment attain the external benefit of compliance without incurring excessive administrative costs.

The next part of the proposition considers the distribution of valuations across the population for choosing $a = 1$ rather than $a = 0$ in the absence of additional inducements, positive or negative. Specifically, the statement employs the concept of a first-order stochastic increase. A distribution F will be said to undergo a first-order stochastic increase to $\tilde{F}$ if $\tilde{F}(v) \leq F(v)$, $\forall v$.

Proposition 1 (b)**.** *As the distribution of the population's valuations for choosing $a = 1$ rather than $a = 0$ undergoes a first-order stochastic increase: the optimal share choosing $a = 1$ increases; this indirectly makes the use of disincentives increasingly attractive relative to the use of incentives; however, the optimal policy intervention and the status quo both provide the social planner greater utility, neither at an unambiguously higher rate than the other.*

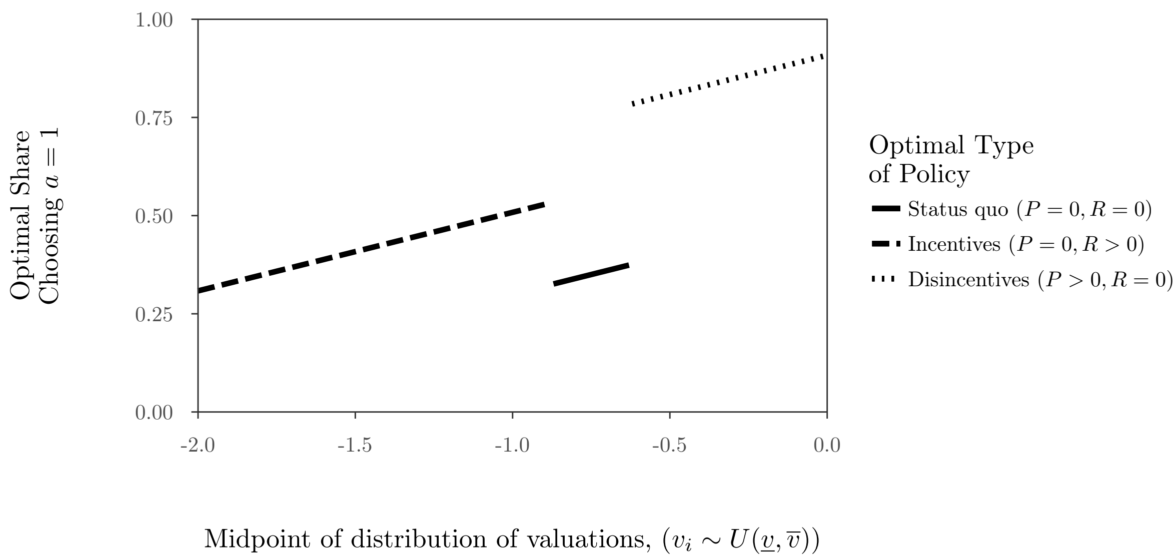
This part of the proposition asks how the social planner's optimal policy would change if the population were *ex ante* more prone to choosing the socially-beneficial behavior, $a = 1$. In a population more prone to choosing the beneficial behavior, fewer individuals must change their behavior in order to achieve a desired share choosing $a = 1$. The policy intervention will be less distortionary, so the negative valuations incurred weigh less heavily on the social planner's calculus. The direct effect is to increase the optimal share of the population choosing $a = 1$.

Similar to the analysis of W, a first-order stochastic increase in F has no direct effect on the attractiveness of using punishments or rewards. Through its effect on the optimal share of the population choosing $a = 1$, however, a first-order stochastic increase in F indirectly favors the use of disincentives rather than incentives. A larger share of the population choosing $a = 1$ drives the administrative cost of using punishments down while driving the administrative cost of using rewards up.

A first-order stochastic increase in F affects the comparison of the optimal policy intervention to the status quo more intricately than the change considered in the first part of the proposition. The social planner's utility from the optimal policy intervention increases, but so does her utility from the status quo through $W(1-F(0))$. A first-order stochastic increase will not always make a policy intervention increasingly attractive relative to the status quo.

Figure 2 illustrates these results. Moving to the right along the horizontal axis, the distribution of valuations, F, shifts upwards, a form of first-order stochastic increase. The example entails a uniform distribution of valuations, and the running variable is the midpoint of the distribution. The optimal share choosing $a = 1$ is increasing when a policy intervention is optimal, and this ultimately favors the use of punishments instead of the use of rewards. It may be, however, that the optimal level of compliance and type of policy "regress" to the status quo even as F continues to shift upwards.

Figure 2: The effect of increasing the *ex ante* valuations for choosing $a = 1$ rather than $a = 0$ on the utilitarian most-preferred share of the population choosing $a = 1$ and type of policy



Notes: The horizontal axis tracks $(\overline{v} + \underline{v})/2$, with $v_i \sim U(\underline{v}, \overline{v})$ (the functional form underlying the figure). An increase in this quantity corresponds to an upward shift in the distribution of valuations $F(\cdot)$, a type of first-order stochastic increase.

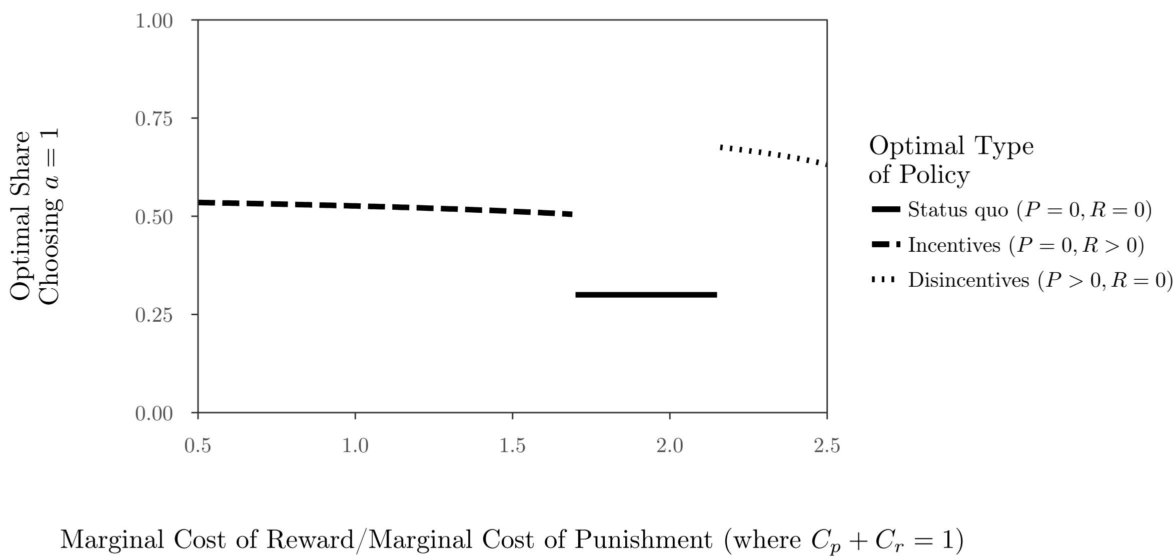
Proposition 1 (c)**.** *A decrease in the marginal cost of using disincentives, with no change in fixed costs, has competing direct effects on the optimal policy intervention. It makes punishments more attractive than rewards, but it reduces the optimal share of the population choosing $a = 1$. The same holds for increases in the marginal cost of using incentives to induce more compliance with $a = 1$.*

The final result in Proposition 1 is surprising precisely because of the ambiguity it highlights. Adjusting the marginal costs of the types of policies would seem to be the most straightforward way to favor one type of policy over the other, but this is not the case. The changes have direct effects on both the optimal share of the population choosing $a = 1$ and the optimal type of policy, but in such ways that the indirect effects of the choice variables on one another find themselves at odds. It is impossible to state – without invoking additional assumptions – that reducing the per-unit administrative costs of a type of policy always favors the use of that policy.

Lowering the marginal cost of either type of policy makes the use of that instrument less costly. The other direct effect of lowering the marginal cost of incentives is to encourage larger interventions, however, and the other direct effect of lowering the marginal cost of disincentives is to encourage smaller policy interventions.[16] The direct effects thus lead to opposing indirect effects.

Figure 3 shows exactly these effects. The running variable is the ratio of the coefficients on the cost terms where, for the purposes of the illustration, each cost function has constant marginal cost. To demonstrate changes in both variables, the coefficients are required to sum to one, although this forces the marginal cost of rewards to increase as the marginal cost of punishment decreases. The optimal level of compliance decreases even as the marginal cost of a disincentive-based policy falls relative to the marginal cost of incentive-based policy. While the optimal type of policy does not switch back to rewards, as the proposition suggests could occur, this is likely because a decrease in C_p is tied to an increase in C_r. Furthermore, the competing effects that occur when marginal costs change allow the status quo to be more attractive than either type of policy intervention at intermediate levels.

Figure 3: The effect of decreasing the marginal cost of disincentives and increasing the marginal cost of incentives on the utilitarian most-preferred share of the population choosing $a = 1$ and type of policy



Notes: The ratio of marginal cost coefficients, c_r/c_p, is increasing along the horizontal axis, under an assumption of constant marginal costs such that $C_r(1-F) = c_r \cdot (1-F)$ and $C_p(F) = c_p \cdot (F)$ (the functional forms underlying the example). For purposes of illustration, $c_p + c_r = 1$, though of course this need not be the case more generally.

[16] A lower marginal cost of disincentives lessens the reduction in cost associated with increasing punishment-based interventions.

5 Incorporating Political Pressures

In contrast to a utilitarian social planner, an office-motivated politician seeks a policy that will garner the support of a majority of the population. This section characterizes the majority-preferred policy and its relationship to the social planner's optimal policy. This task requires deeper engagement with the redistributive consequences of different types of policies than was necessary above.

It is helpful to clarify the utility a given member of the population, i, receives from a policy (P, R). The subscript 1 indicates that i chose $a = 1$, while 0 indicates that i chose $a = 0$. Fact 1 from above determines when an individual will and will not comply, for which the utility function below accounts. Indeed, $U^i(P, R)$ is the upper envelope of $U^i_1(P, R)$ and $U^i_0(P, R)$. It reflects i's utility under her best choice of action, $a^i \in \{0, 1\}$. It is still the case that $1 - F(-R - P)$ is the proportion of the population that chooses the desired behavior, $a = 1$, given punishment of size P and reward of size R.

$$U^i(P,R) = \begin{cases} U^i_1(P,R) = \\ W(1 - F(-R-P)) + F(-R-P)(P+R) - C_p(F(-R-P)) - C_r(1-F(-R-P)) + v^i \\ \hfill \text{if } v^i \geq -R-P \\ U^i_0(P,R) = \\ W(1 - F(-R-P)) - [1 - F(-R-P)](P+R) - C_p(F(-R-P)) - C_r(1-F(-R-P)) \\ \hfill \text{if } v^i < -R-P \end{cases} \tag{2}$$

Fact 2. *The policy that maximizes a member of the population's utility will maximize the utility of all those who made the same choice.*

Letting $(P^{**}_1, R^{**}_1) := \arg\max_{(P,R)} U^i_1(P, R)$, then (P^{**}_1, R^{**}_1) is the policy that maximizes utility for all members of the population that choose $a = 1$. Letting $(P^{**}_0, R^{**}_0) = \arg\max_{(P,R)} U^i_0(P, R)$, then (P^{**}_0, R^{**}_0) is the policy that maximizes utility for all who chose $a = 0$. These cases include $(P^{**}_1, R^{**}_1), (P^{**}_0, R^{**}_0) = (0, 0)$.

Remark 1. *No restriction that $P, R \geq 0$ appears here, as it did above.*

The quantity P continues to refer to a policy applied to those who choose $a = 0$, where negative values of P would correspond to a policy rewarding those that choose $a = 0$. Similarly, R continues to refer to a policy applied to those who choose $a = 1$, where negative values of R would correspond to a policy punishing those that choose $a = 1$. These policies would encourage socially harmful actions or discourage socially beneficial behavior. The possibility of $P, R < 0$ receives further attention below.

The next result establishes that the preference of the individual with the median valuation for compliance is equivalent to the majority preference, as the support of the individual with the median valuation, henceforth the "median voter" (MV), is necessary and sufficient for majority support. The median voter's most-preferred policy would be the winning policy in an election between two office-motivated candidates competing over binding policy proposals in which all members of the population cast exactly one vote according to the weakly dominant strategy of voting for the candidate whose proposal offers them greatest utility. Denote this policy $(P^{**}, R^{**}) := \arg\max U^{MV}(P, R)$, where $v^{MV} := F^{-1}(1/2)$.

Lemma 3. *There does not exist a policy more preferred by a majority of individuals than* (P^{**}, R^{**}).

For the majority preference relation to be equivalent to the preference relation of the individual with the median valuation, v^{MV}, the profile of preferences across the population must satisfy monotonicity with respect to the valuations. Fact 2 above implies that, for all i, $\arg\max_{(P,R)} U^i(P, R) \in \{(P_1^{**}, R_1^{**}), (P_0^{**}, R_0^{**})\}$. The proof then demonstrates the existence of a threshold valuation such that all members of the population with valuations above the threshold prefer (P_1^{**}, R_1^{**}), while those with valuations below the threshold prefer (P_0^{**}, R_0^{**}). This demonstrates the monotonicity of preferences in the valuations necessary to invoke the median voter theorem (Gans & Smart 1996).

This result establishes that if $(P^{**}, R^{**}) = (P_1^{**}, R_1^{**})$, then the median voter along with a majority of the population will choose $a = 1$ under the policy that receives majority support. Conversely, if $(P^{**}, R^{**}) = (P_0^{**}, R_0^{**})$, then the median voter along with a majority of the population will choose $a = 0$ under the policy that receives majority support. If $(P^{**}, R^{**}) = (0, 0)$, such that the median voter prefers no policy intervention, then so, too, will the majority of the population that choose the same action as the median voter in the absence of incentives or disincentives.

6 The Majority-Preferred Policy

To understand the winning policy from Lemma 3, (P^{**}, R^{**}), the next task is to characterize (P_1^{**}, R_1^{**}) and (P_0^{**}, R_0^{**}). As with the social planner, no member of the population would employ both types of policy to induce the same share of the population to choose $a = 1$. It may still be that no active policy intervention is the most preferred.

Lemma 4. *All members of the population prefer the use of either an incentive or a disincentive policy – but not both – to induce any given share of the population choosing* $a = 1$.

This insight follows from precisely the same logic as it did for the social planner in the previous section. The possibility remains that for some exogenous change, the status quo (i.e., $P = 0, R = 0$) becomes increasingly attractive as incentive- or disincentive-based policies also become more or less attractive relative to the other. As such, and similar to the social planner's optimal policy, characterizing the overall majority-preferred policy requires some care, and results primarily focus on the majority-preferred policies that actually entail an intervention, as defined below.

Definition 2 (Majority-Preferred Policy Intervention)**.** *The most preferred policy intervention by the member of the population with the median valuation for choosing $a = 1$ rather than $a = 0$, characterized by a majority-preferred level of compliance and a majority-preferred type of policy that together specify $P^{**} \neq 0$ or $R^{**} \neq 0$.*

A complementarity exists under the majoritarian perspective, as under the utilitarian perspective, between inducing high shares of the population to choose $a = 1$ and the use of policies applied to those choosing $a = 0$ instead of policies applied to those choosing $a = 1$. The majority-preferred policy and the social planner's optimal policy are not the same, however, and the most interesting characterization of the majority-preferred policy is in relation to the utilitarian's optimal policy. This is the focus of the next proposition, which states that the majority-preferred policy intervention "sandwiches" the social planner's optimal policy intervention first from below and then from above as compliance with $a = 1$ increases. The utilitarian and majoritarian optimal policies only coincide when each prefers the status quo to their preferred policy intervention.

Proposition 2. *Comparing the majority-preferred policy intervention ($P^{**} \neq 0$ or $R^{**} \neq 0$) to the social planner's optimal policy intervention ($P^* > 0$ or $R^* > 0$):*

A majority will neither punish itself for choosing $a = 0$ nor reward a minority who choose $a = 1$ sufficiently to achieve the social planner's optimal share of the population choosing $a = 1$.

A majority will either reward itself for choosing $a = 1$ or punish a minority who choose $a = 0$ excessively, achieving a higher share of the population choosing $a = 1$ than the social planner would.

Conditions changes that affect the attractiveness of a higher share of the population choosing $a = 1$, such as a change in the marginal societal benefit, favor two of these outcomes: a majority choosing $a = 1$ and imposing a larger-than-optimal disincentive on the minority choosing $a = 0$; a majority choosing $a = 0$ and instituting a smaller-than-optimal incentive for the minority choosing $a = 1$.

The implications regarding majority behavior follow immediately from the fact that the median voter chooses $a = 1$ if and only if a majority of individuals are also choosing $a = 1$. The median voter's choice of $a = 1$ is a monotonically increasing step function of the share of the population choosing $a = 1$. Parameter changes that lead to an increase in the share of the population choosing $a = 1$ naturally make it more likely that the median will choose $a = 1$.

Viewed another way, the *ex post* action of the median voter, the overall level of compliance, and the type of policy are jointly determined in finding the majority-preferred policy, as the latter two were jointly determined in finding the social planner's optimal policy. The three decisions display weak pairwise complementarity. As noted, the use of punishments (vis-à-vis rewards) and inducing more compliance with $a = 1$ remain complements. Additionally, the median voter's choice of $a = 1$ (instead of $a = 0$) and the share of the population induced to choose $a = 1$ are complements (no direct relationship exists between the median voter's action choice and the choice between incentives or disincentives). These two complementarities have the effect of amplifying one another.

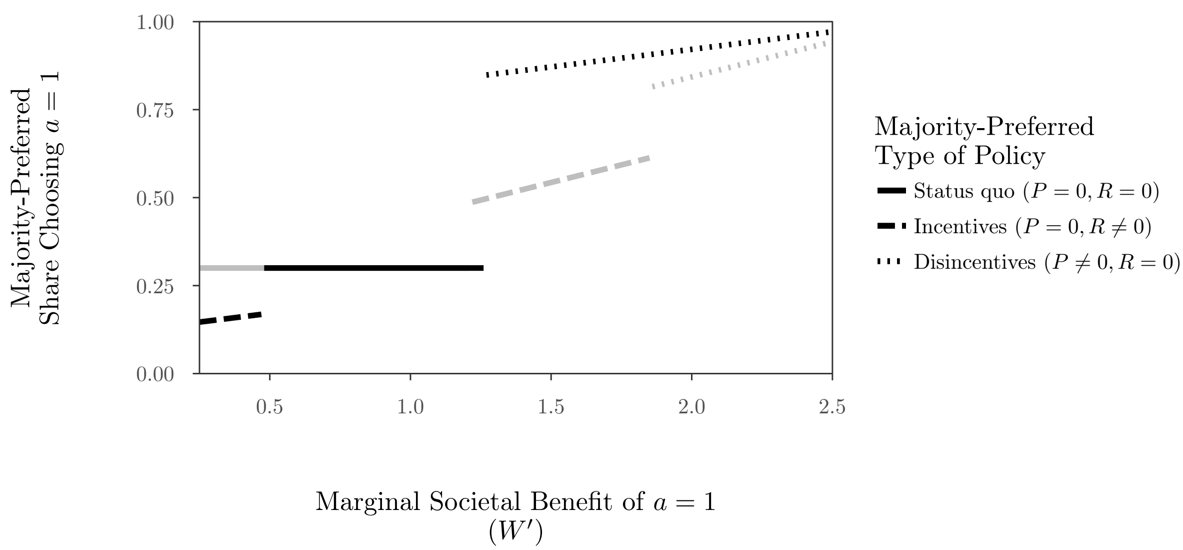
A member of the population choosing $a = 1$ *ex post* has a marginal utility function that is the same as the utilitarian social planner's, save for the redistributive implications. The utilitarian is neutral to transfers, balancing the loss to some against the benefit for others. The *ex post* complier, however, benefits from transfers and does not internalize the negative effects of transfers on non-compliers. The *ex post* complier thus has a higher marginal net benefit at all levels of compliance. A member of the population choosing $a = 0$ *ex post* has a marginal utility function that is the same as the policymaker's, but with a lower marginal net benefit at all levels of compliance. She internalizes the redistributive losses but receives none of the redistributive gains.

With the above comparisons in hand, Proposition 1(a) provides the results necessary to compare the median voter's and the social planner's preferred policies. Maximizing utility given a choice of $a = 1$ will lead to greater levels of compliance than the social planner's optimal level and, indirectly, favor the use of punishments over rewards. Maximizing utility given a choice of $a = 0$ will lead to lower levels of compliance than the social planner's optimal level and, indirectly, favor the use of reward-based policies over the use of punishment-based policies. It follows that, relative to those choosing $a = 0$, members of the population choosing $a = 1$ will desire higher levels of compliance and thus favor the use of punishment-based policies. Meanwhile, the use of disincentive policies favors larger policy interventions, which in turn favors majority compliance with $a = 1$.

As Proposition 2 states, a majority may excessively reward itself for choosing $a = 1$ or excessively punish a minority for choosing $a = 0$; alternatively, a majority may insufficiently reward a minority choosing $a = 1$ or insufficiently punish itself for choosing $a = 0$. That a majority would ever choose to punish its own harmful behavior or reward its own beneficial behavior is perhaps counterintuitive, and in fact, these two outcomes are less likely in a sense. Conditions that lead higher shares and ultimately a majority to choose $a = 1$ (resp. $a = 0$) indirectly increase the attractiveness of punishments (resp. rewards) due to the complementarity between high shares of the population choosing $a = 1$ and the use of disincentives rather than incentives.

Figure 4 illustrates these results. The darker, black lines correspond to the majority-preferred share of the population choosing $a = 1$ and the line types indicate the type of policy. The gray lines correspond to the social planner's optimal share choosing $a = 1$, and the line types again indicate the type of policy. The gray lines lie above and then below the black lines, switching when the policy intervention would induce the median voter to choose $a = 1$ instead of $a = 0$. The median voter's preferred policy will not achieve the social planner's preferred share of the population choosing $a = 1$, unless both prefer the absence of a policy intervention, the status quo. Because conditions that favor more of the population choosing $a = 1$ also favor the use of punishments, the majority-preferred policy intervention will tend to use punishments when larger than the social planner's and rewards when smaller than the social planner's.[17]

Figure 4: The effect of increasing the marginal benefit to society of the share of the population choosing $a = 1$ on the majority-preferred share of the population choosing $a = 1$ and type of policy



Notes: The black lines correspond to the majority-preferred share of the population choosing $a = 1$, with line types indicating the type of policy. The gray lines correspond to the utilitarian-optimal share choosing $a = 1$, with the same line types indicating the type of policy.The horizontal axis tracks increases in W', the marginal societal benefit, which is equal to g when societal benefit is given by $g \cdot [1 - F(-R - P)]$ (the functional form underlying the figure).

Encouraging the Socially Harmful Action

An at-first jarring feature of the above results is the possibility that members of the population choosing $a = 1$ might be punished or that those choosing $a = 0$ might be rewarded. It would never have been optimal for the social planner to implement $P, R < 0$. In the context of popular support, however, encouraging the socially

[17]Of course, examples do exist of insufficiently large punishments that the majority levies on itself for choosing $a = 0$. The proliferating taxes on sugary drink purchases – often quite small – appear to be such a policy.

desirable action garners support among the population only in as much as the social benefit contributes to utility enough to outweigh redistributive concerns. The median voter need not take into account any valuations other than her own, save for the role the valuations play in determining compliance.

Any of the cases in Proposition 2 may involve "negative rewards" for choosing $a = 1$ (fine for choosing $a = 1$) or "negative punishments" for choosing $a = 0$ (subsidy for choosing $a = 0$). However, a majority-preferred policy that deters the choice of $a = 1$ will likely entail $R^{**} < 0$. It involves low shares of the population choosing $a = 1$ (with the median voter likely choosing $a = 0$), so it follows that a policy that applies to those choosing $a = 1$ would be the least costly.

Corollary 1. *Exogenous changes that decrease the attractiveness of a lower share of the population choosing* $a = 1$*, such as a decrease in the marginal societal benefit of compliance, directly favor a majority-preferred policy that induces lower shares of the population to choose* $a = 1$ *ex post than would have ex ante and also indirectly favor the use of policies that apply to members of the population choosing* $a = 1$*, i.e.,* $P^{**} = 0, R^{**} < 0$*, a fine ("negative reward") administered to those choosing the beneficial action.*

The majority-preferred policy induces even smaller shares of the population to choose $a = 1$ than the utilitarian's optimal policy when the median voter chooses $a = 0$ *ex post.* The complementarity between low shares choosing $a = 1$ and the use of rewards favor the use of policies applied to those choosing $a = 1$. At the extreme, these "rewards" are so small as to become fines for those choosing the socially beneficial action (see Figure 4). While such policies appear radically different than policies encouraging the socially-beneficial behavior, it is important to note that a policy barely encouraging the beneficial behavior and a policy barely discouraging the beneficial behavior provide the median voter nearly equivalent utility. As such, conditions giving rise to a policy encouraging $a = 1$ and a policy discouraging $a = 1$ may be more similar than their stated intentions suggest.

7 Accounting for Unaffected Subpopulations

The model has thus far set aside the possibility that the policy applies only to a "subpopulation of interest," while the population at-large is not confronted with a choice between $a = 1$ and $a = 0$. This may take one of two forms: 1) it is not possible to distinguish the subpopulation of interest from the rest of the population for the sake of applying the policy, 2) it is possible to administer the policy only to the subpopulation of interest. The former receives attention first, and it requires only an informal discussion as an application of earlier results covers this case without difficulty.

When the subpopulation of interest is indistinguishable from the population at-large and the subpopulation not of interest tacitly chooses $a = 1$ (e.g., non-drivers not speeding), it is as though the distribution of valuations for the whole population is a first-order stochastic increase of the distribution of valuations of the subpopulation of interest (drivers). Invoking Proposition 1(b), this favors the use of disincentives. In the example of discouraging speeding, this formalizes the intuition that rewarding a substantial segment of the population (non-drivers) for not speeding (when they were at no risk of doing so anyway) would be incredibly inefficient. From the utilitarian's perspective, these conditions favor the use of fines and inducing a high share of the population choosing to drive safely (or not at all), and the fines would likely be even larger if majority-preference dictated the choice of policy.

In the context of copyright for artistic works, or patents for inventions, government wishes to encourage innovation, but it is unable to target the subpopulation of possible innovators, artistic or otherwise. This constitutes the presence of a large subpopulation that is not disposed to "comply" with the behavior government wishes to encourage. As such, the distribution of valuations of the population as a whole is less prone to choose $a = 1$ than the distribution of valuations within the subpopulation of interest. Referencing Proposition 1(b) again, these conditions lead a utilitarian to favor using rewards to spur innovation by a small share of the overall population. The implies the majority-preference would be for a smaller-than-optimal reward, which foots with oft-heard complaints from innovators across fields, namely, that the reward is insufficient compensation for their creative effort.

In many circumstances, however, it is easy to differentiate those in a subpopulation of interest from those who are not. For instance, a policymaker may wish to target an industry. It is usually straightforward to identify firms from individuals and, further, firms in a certain industry from firms in other industries. Those who do not own cars would not be penalized for failure to possess vehicle registration, and those without cropland would be ineligible for farm subsides. Call the portion of the population that would receive neither a reward nor a punishment under a given policy the "unaffected subpopulation." The "subpopulation of interest" still refers to the portion of the population to whom any incentive or disincentive would apply.

If enforcement is able to discriminate between the subpopulation of interest and the rest of the population, then the analyses of the utilitarian's optimal policy hold without further modification. The policymaker may ignore redistributive implications for subpopulations not directly affected by the policy, as she could with redistributive implications for individuals in the subpopulation affected by the policy. In the analysis of the popular support for incentive and disincentive policies, however, the presence of an unaffected subpopulation will materially affect the analysis. The unaffected subpopulation certainly reaps social benefit from compliance with the desired behavior in the subpopulation of interest. Furthermore, members of the unaffected subpopulation must also contribute to the financing of subsidies, but they may likewise benefit from the redistribution of fines or taxes collected.

Let the size of the subpopulation not directly affected by the policy, i.e., not eligible for a reward or punishment, be given by $\lambda \in (0,1)$. Denote an arbitrary member of this group by ℓ. The entire population is still of mass 1, so the size of the subpopulation of interest is of mass $1-\lambda$.

Under a policy that involves the use of rewards (as well as potentially punishments), ℓ would have to contribute $(1-\lambda)\cdot R\cdot(1-F(-R-P))+C_r((1-\lambda)\cdot[1-F(-R-P)])$ to finance the subsidy, but receive no compensation for her behavior other than social benefit given by $W((1-\lambda)\cdot[1-F(-R-P)])$. With regards to policies applied to those choosing $a=1$, then, ℓ's utility function takes the same form as a member of the subpopulation of interest who chooses $a=0$. In contrast, under a punishment-based policy, ℓ will not receive any fine, but she will receive $(1-\lambda)\cdot P\cdot F(-R-P)-C_p((1-\lambda)\cdot F(-R-P))$ and $W((1-\lambda)\cdot[1-F(-R-P)])$. With regards to policies applied to those choosing $a=0$, ℓ shares the same utility function as a member of the subpopulation of interest who chooses $a=1$. Accordingly, maximizing ℓ's utility entails comparing the most-preferred punishment-based policy for a member of the sub-population of interest who *ex post* chooses $a=1$ to the most-preferred reward-based policy for a member of the sub-population of interest who *ex post* chooses $a=0$, and then comparing the best of those to the utility ℓ receives in the absence of any further policy intervention, namely $W((1-\lambda)(1-F(0)))$.

The final result characterizes the preferences of a member of an unaffected subpopulation, focusing on the utilitarian-optimal policy intervention and the majority-preferred policy intervention. Assume that the share of the population that is unaffected by the policy is given by $\lambda \in (\frac{1}{2},1)$, such that a majority of the population will receive neither incentive nor disincentive under a policy intervention. As above, let $P^{**}\neq 0$ denote the best disincentive policy intervention from the perspective of a member of the subpopulation of interest that chooses $a=1$ (i.e., $v^i > -P^{**}$). Let $R^{**}\neq 0$ denote the best policy intervention from the perspective of a member of the subpopulation of interest that chooses $a=0$ (i.e., $v^i < -R^{**}$).

Corollary 2. *When the unaffected subpopulation is larger than the subpopulation of interest, majority-preferred policy will entail either a larger-than-optimal disincentive applied to those choosing $a=0$ or a smaller-than-optimal incentive applied to those choosing $a=1$ (potentially a "negative reward," punishing those who choose $a=1$).*

When a subpopulation not directly affected by incentives or disincentives in a given policy domain is sufficiently large so as to decide the policy for the entire population, it will always be the case that rewards will achieve smaller than the socially optimal share of the population choosing $a=1$ and punishments will achieve larger than the socially optimal share of the population choosing $a=1$. This was the tendency noted at the end of Proposition 2, but incorporating the unaffected subpopulation makes this a certainty.

An increase in the marginal benefit to society of members of the affected subpopulation choosing $a=1$ rather than $a=0$ increases the utility ℓ receives from P^{**} and decreases the utility ℓ receives from R^{**}. A similar statement holds for first-order stochastic increases in the distribution of valuations for choosing $a = 1$ rather than $a = 0$ among the subpopulation of interest. Per Corollary 1, the downward pressure on rewards may drive them to become negative, constituting a disincentive for choosing $a = 1$.

The onerous fines that farms incur to receive organic certification are an example of a negative reward applied to those in a small subpopulation of interest that take a socially beneficial behavior. The low marginal benefit of a given (usually small) farm choosing to adopt organic practices favors the use of policies applied to those choosing $a = 1$, which further leads to smaller-than-optimal (even negative) incentives. That such a policy would generate revenue to be redistributed among the population-at-large would only help to overcome the loss of social benefit for a member of the unaffected subpopulation.

8 Conclusion

This paper began with a set of straightforward yet previously neglected questions: Should policy seeking to encourage a behavior offer incentives to those who take it or threaten disincentives to those who do not? What type of policy would a majority of the population support, and how will this differ from what a public-interested policymaker would choose? How do these answers change in response to the different conditions across policy domains?

Adopting both utilitarian and majoritarian perspectives, a complementarity between the use of disincentives (vis-à-vis incentives) and inducing large shares of the population to take the beneficial behavior was central to the analysis. Inducing larger shares of the population to take the beneficial action becomes more attractive as the incremental benefit to doing so increases or as the population becomes more prone to take the beneficial behavior absent any policy interventions. In turn, this favors the use of disincentives. The complementarity driving these results only grew stronger when accounting for the redistributive consequences of incentives and disincentives across members of the population, especially for those not directly affected by the policy. A majority will tend to prefer larger punishments for those choosing the harmful action and smaller rewards for those choosing the beneficial action than a social planner would prefer. Policies that entail a disincentive for taking the beneficial action emerge as an example of a smaller-than-optimal reward for those taking the beneficial action; the reward is so small as to be negative. The spirit of a policy encouraging the beneficial action and a policy discouraging it could not be more opposed, but the model demonstrates the highly similar redistributive implications of the two for the median voter, in whose eyes the policies are not so different.

Future work would do well to focus on inequality. Characterizing the implications of incentives and disincentives for inequality would be a first step. Additionally, a better understanding of policy choice based on the correlation of one's wealth and one's valuation for taking socially beneficial/harmful actions could produce an array of new insights about the use of incentives and disincentives in public policy.

Incorporating population-based behavioral effects, such as crowding in/out, norms, or coordination in interactions among the population would offer a bridge between this paper's rather stark rational choice account and the behavioral studies of the ways in which people and groups respond to policy interventions. Would the complementarities highlighted above persist in such settings? This remains an open question.

Another means of engaging with the behavioral literature would involve the political economy of "scaling up." Many interventions begin with pilot initiatives that entail incentives, such as those rewarding children to make better choices over school lunch options (Just & Price 2013, List & Samek 2017). While discussions of expansion usually focus on the extensive margin, rolling the program out to other venues, a clear implication of small-scale success would be an expansion along the intensive margin, scaling up the size of the intervention at all venues. The model warns, however, that as larger shares of the population are induced to choose a desired action, the optimal policy instrument would shift to disincentives, and popular support for rewards would wane dramatically.

Indeed, this was likely a factor in the failed attempts at healthcare reform. Granting subsidies across the board – including to segments of the population that required subsidies neither to pay for insurance nor to nudge them into insuring themselves – was innately inefficient. Incentives would only be optimal if most of the external benefit to society from individuals being insured accrued with only small shares of the population purchasing insurance. Insurance markets, however, are precisely the type of setting for which the shared benefit of additional participation remains high even when only a small share of the population is not participating. This feature of the health policy domain further favors the use of disincentives, such as those implicit in the mandate. The veracity of popular support for the ACA, at least in the face of any of the suggested reforms, was particularly strong, as the model would predict.

This case suggests a key feature of the political environment that would likely enrich future work using this model a great deal. If political parties group members of the population such that each party's membership systematically differs from the others in their evaluations of the externalities prompting policy intervention, and if there exists a correlation between party membership, wealth, and propensity to take the beneficial action, then it is almost certain that the parties will support vastly different policy interventions. Moving away from a strictly majoritarian view of the political process and incorporating party politics emerges as a particularly worthwhile direction for future study on the decision between incentives and disincentives.

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Online Appendix

The appendices include proofs of the results in text, as well as – in many cases – a more formal statement of the result. The informal statements found in the text follow immediately from the corresponding results below.

A Proofs from Section 3-4: Utilitarian Perpsective

A.1 Reframing the utilitarian's problem

Lemma 1. *It is never optimal to use strictly positive levels of both punishments and rewards.*

Proof of Lemma 1. Recall that $C_p(\cdot)$ and $C_r(\cdot)$ are increasing in their arguments, F and $1-F$, respectively. As such, there either exists a share of the population taking $a = 1$, denote it $1 - \tilde{F}$, such that $C_p(\tilde{F}) = C_r(1-\tilde{F})$, or it must be true that $C_p(1) < C_r(0)$ or $C_p(0) > C_r(1)$. In the latter two possibilities, disincentives or incentives, respectively, are the cheapest policy instrument at any share of the population choosing $a = 1$.

Suppose the first case obtains, where $1 - \tilde{F} \in (0, 1)$ and $C_p(\tilde{F}) = C_r(1 - \tilde{F})$. For all lower shares taking $a = 1$, $1 - F < 1 - \tilde{F} \Rightarrow C_r(1 - F) < C_p(F)$, so rewards are the cheaper type of policy with which to attain a given level of compliance. Conversely, for higher shares of the population taking $a = 1$, $1 - F > 1 - \tilde{F} \Rightarrow C_p(F) > C_r(1 - F)$, so punishments are the cheaper type of policy with which to attain a given level of compliance. At $1 - \tilde{F}$, either type of policy entails the same administrative cost, but only one should be used so that costs are not incurred twice to achieve compliance of $1 - \tilde{F}$. To induce any share of the population to choose $a = 1$, then, only one type of policy should be employed. ■

Remark 2. *It is worth clarifying the generality with which this result holds. Given the model's somewhat simplistic assumptions, especially with regards to the accrual of costs, it emerges rather starkly that it is never optimal to employ strictly positive levels of punishment and reward to achieve precisely the same end. The finding, however, does not rely on such assumptions. The result and even the same proof approach are still valid if both of the administrative cost terms increase in the size of the intervention (i.e., P, R) in addition to increasing in the measure of the population to which they are applied (i.e., $F, 1-F$). In that case, the marginal cost of administering punishment-based policies overtakes the marginal cost of administering reward-based policies. As such, there exists a share choosing $a = 1$ at which one would not only be indifferent between using incentive and disincentive policies, but at which one would be willing to use any mixture of the two policies to induce that share of the population to choose $a = 1$. Yet this will never be the share choosing $a = 1$ at which the marginal administrative costs are equal, so it will still be true that the optimal policy using* *only punishments or the optimal policy using on rewards achieves higher social welfare and entails a different level of compliance. The level at which the costs are equal, $1 - \tilde{F}$, always constitutes a local minimum or a cusp, but never a local or global maximum.*

To reframe the social planner's problem as discussed in text, we denote a type of policy by $\theta \in \{p, r, \phi\}$, with p denoting the use of punishments, r denoting the use of rewards, and ϕ denoting the absence of a policy intervention. We adopt the ordering $p > r$ for the subset $\{p, r\}$. We leave ϕ out of the ordering, as per the discussion in text, considering it to be a subsequent decision. We denote the share of the population taking $a = 1$ *ex post* by Γ.

Given a distribution of valuations, F, Γ uniquely defines the size of the policy intervention, which we refer to by X. We may define $X = P + R$, although recall that Lemma 1 establishes that at most one of P or R will be strictly greater than zero. The relationship is given by $X(\Gamma) = -F^{-1}(1 - \Gamma)$. The choice to forgo a policy intervention is given by $(\Gamma_{\emptyset}, \phi)$.

Lemma 5 establishes that the (Γ, θ) choice problem yields identical solutions to the original formulation in which the policymaker chose an optimal (P, R). Were $(P^*, 0)$ the optimal policy under the original formulation, and (Γ^*, θ^*) is the optimal policy under the reframing, then $\theta^* = p$ and $\Gamma^* = 1 - F(-P^*)$; the analogous statement holds for R. Lemma 1 plays a crucial role in the proof.

Lemma 5. $(\Gamma^*, \theta^*) := \arg\max_{\Gamma \geq \Gamma_{\emptyset}, \theta \in \{\phi, r, p\}} W(\Gamma) - \int_0^{\Gamma} X(\tilde{\Gamma}) d\tilde{\Gamma} - C_{\theta}(\Gamma)$ *iff* $(\mathbb{I}_{\theta^*=p} \cdot X(\Gamma^*), \mathbb{I}_{\theta^*=r} \cdot X(\Gamma^*)) = (P^*, R^*) := \arg\max_{P \geq 0, R \geq 0} W(1 - F(-R - P)) + \int_{-R-P}^{\overline{v}} v f(v) dv - \mathbb{I}_{P>0} C_p(\Gamma) - \mathbb{I}_{R>0} C_r(\Gamma)$.

NB: $C_p'(\Gamma) < 0$, while $C_r'(\Gamma) > 0$, where each derivative is taken with respect to Γ.

Proof of Lemma 5. By Lemma 1, we know that the optimal policy, (P^*, R^*) lies in the set $\{(P, 0) | P \geq 0\} \cup \{(0, R) | R \geq 0\}$.

By the independence of irrelevant alternatives axiom, we know that eliminating the set of policies $\{(P, R) | P > 0, R > 0\}$ and maximizing over $(P, R) \in \{(P, 0) | P \geq 0\} \cup \{(0, R) | R \geq 0\}$ instead of $(P, R) \in \mathbb{R}^2_+$ will yield the same solutions.

Then consider (P^*, R^*) and (Γ^*, θ^*), and recall the one-to-one and onto transformation between the two pairs. If $(\mathbb{I}_{\theta^*=p} \cdot X(\Gamma^*), \mathbb{I}_{\theta^*=r} \cdot X(\Gamma^*)) \neq (P^*, R^*)$, then some other $(\tilde{P}, \tilde{R})$ is the solution to maximizing social welfare using the (P, R) formulation. This would contradict the supposition that (P^*, R^*) were the optimal choices of punishment and reward. The same argument in reverse (from (P^*, R^*) to (Γ^*, θ^*)) completes the proof. ∎

We rewrite the social planner's utility function in accordance with the above transformation:

$$U^{SP}(\Gamma,\theta) = \begin{cases} U_p^{SP}(\Gamma) = W(\Gamma) - \int_0^{\Gamma} X(\tilde{\Gamma})d\tilde{\Gamma} - C_p(\Gamma) & \text{if } \Gamma > \Gamma_{\emptyset}, \theta = p \\ U_r^{SP}(\Gamma) = W(\Gamma) - \int_0^{\Gamma} X(\tilde{\Gamma})d\tilde{\Gamma} - C_r(\Gamma) & \text{if } \Gamma > \Gamma_{\emptyset}, \theta = r \\ U_{\phi}^{SP}(\Gamma) = W(\Gamma) - \int_0^{\Gamma} X(\tilde{\Gamma})d\tilde{\Gamma} & \text{if } \Gamma = \Gamma_{\emptyset}, \theta = \phi \end{cases} \cdot \tag{3}$$

The restriction to $(P, R) \geq 0$ becomes $\Gamma \geq \Gamma_{\emptyset} := 1 - F(0)$, which we impose on the social planner's transformed maximization problem.

Ashworth & Bueno de Mesquita (2006) provide conditions of complementarity, formally supermodularity, under which monotone comparative statics hold without further parameterization. Specifically, we seek to show each pair of arguments of the utility function has increasing differences (or when this is not possible the weaker single-crossing property). Increasing differences amounts to demonstrating that the incremental return of each of argument is increasing in the other.

We derive these results in reference to U^{SP}, where $\theta \in \{p, r\}$. In effect, we treat the comparison to status quo utility under $(\Gamma_{\emptyset}, \phi)$ as a second step, after first choosing between p and r. In the context of Equation 3, we say U^{SP} has increasing differences in the level of compliance achieved, Γ, and the choice of policy type, $\theta \in \{p, r\}$, if for all $\hat{\Gamma} > \Gamma$ and $\hat{\theta} > \theta$ (i.e., $p > r$),

$$U^{SP}(\hat{\Gamma}, \hat{\theta}) - U^{SP}(\Gamma, \hat{\theta}) \geq U^{SP}(\hat{\Gamma}, \theta) - U^{SP}(\Gamma, \theta). \tag{4}$$

Indeed, this does hold for the social planner's objective function, reducing to

$$-C_p(\hat{\Gamma}) - C_p(\Gamma) \geq -C_r(\hat{\Gamma}) + C_r(\Gamma), \tag{5}$$ [18]

where the left-hand side is positive and the right-hand side is negative.

An increase in the level of compliance (Γ's incremental return) is more attractive under the use of disincentives than under the use of incentives (an increase in θ). Equivalently, the use of punishments is more attractive relative to the use of rewards (θ's incremental return) as compliance (Γ) increases. This is a direct result of the asymmetric way in which costs accrue under incentive and disincentive policies.

If it can then be shown that U^{SP} has increasing differences with respect to an exogenous parameter and each of the choice variables, then we may conclude that an increase in that parameter leads to an increase in the choice of (Γ, θ) in the optimal policy intevention, i.e., when $\Gamma > 0, \theta \neq \phi$. We need not worry about

[18] This constitutes a proof of Lemma 2.

indirect effects. The pairwise complementarity of parameters and choice variables (i.e., supermodularity) ensures that any indirect effects only enhance the direct effects. We then ask how the utility given by the optimal choice of a "non-zero" policy intervention changes relative to the status quo utility under $(\Gamma_\emptyset, \phi)$ in response to parameter changes, although our primary interest lies in the optimal policy intervention.

A.2 Comparative statics of utilitarian social planner's optimal policy

Proposition 1' (a)**.** *Let the optimal level of compliance,* $\Gamma \in [\Gamma_\emptyset, 1]$*, and type of policy,* $\theta \in \{p, r, \phi\}$*, under the function* W *be given by* (Γ^*, θ^*)*. Let* $(\hat{\Gamma}^*, \hat{\theta}^*)$ *be the optimal compliance and policy under* $\hat{W}$*.*

If $\hat{W}' \geq W'$*, such that the marginal benefit of compliance under* $\hat{W}$ *is weakly higher than under* W *for all levels of compliance, then* $\hat{\Gamma}^* \geq \Gamma^*$*. If* $\Gamma^* > \Gamma_\emptyset$*, then* $\hat{\theta}^* \geq \theta^*$*.*

Proposition 1' (b)**.** *Let* (Γ^*, θ^*) *be the optimal level of compliance and type of policy under the distribution of valuations* F*. Let* $(\hat{\Gamma}^*, \hat{\theta}^*)$ *be the optimal compliance and policy under* $\hat{F}$*.*

If $\hat{F} \leq F$*, such that* $\hat{F}$ *first-order stochastically dominates* F*, and if* $\Gamma^*, \hat{\Gamma}^* > \Gamma_\emptyset$*, then* $\hat{\Gamma}^* \geq \Gamma^*, \hat{\theta}^* \geq \theta^*$*.*

Proposition 1' (c)**.** *Let* (Γ^*, θ^*) *be the optimal level of compliance and type of policy under the function* C_p*. Let* $(\hat{\Gamma}^*, \hat{\theta}^*)$ *be the optimal compliance and policy under* $\hat{C}_p$*. Further, suppose* $\hat{C}'_p \leq C'_p$*, such that the marginal cost of punishing non-compliers is weakly less under* $\hat{C}_p$ *than under* C_p *for all levels of compliance.*

A change from C_p *to* $\hat{C}_p$ *increases the incremental return of* U^{SP} *from an increase in* Γ *but decreases the incremental return of* U^{SP} *with respect to a change from* $\theta = r$ *to* $\theta = p$*. As such, the relationships of* $\hat{\Gamma}^*$ *to* Γ^* *and* $\hat{\theta}^*$ *to* θ^* *are ambiguous, even if* $\Gamma^*, \hat{\Gamma}^* > 0$*.*

The same is true for C_r *and* $\hat{C}_r$*, where* $\hat{C}'_r \leq C'_r$ *such that the marginal cost of rewarding compliers is weakly greater under* $\hat{C}_r$ *than under* C_r *for all levels of compliance.*

Proof of Proposition 1*.* We seek to apply Theorem 5 from Milgrom & Shannon (1994). We have already shown in text that U^{SP} is supermodular in (Γ, θ). Additionally, $\{[\Gamma_\emptyset, 1] \times \{p, r\}\}$ is a lattice satisfying the necessary condition on the set from which the choice variables (Γ, θ) are drawn. It remains to be shown whether U^{SP} has increasing differences in $(\Gamma, \theta; W(\cdot), F(\cdot), C_p(\cdot), C_r(\cdot))$, with partial orderings for the latter four arguments supplied in the Proposition and further clarified below. To do so, we must demonstrate increasing differences in each choice variable-parameter pair.

For Propositions 1(a)-(b), our aim is to show U^{SP} does have increasing differences in $(\Gamma, \theta; W(\cdot), F(\cdot))$. If so, the optimal policy intervention, $(\Gamma^*, \theta^*) = \underset{(\Gamma,\theta)\in\{[\Gamma_\emptyset,1]\times\{p,r\}\}}{\arg\max} U^{SP}(\Gamma, \theta; W(\cdot), F(\cdot))$, is monotone non-decreasing in $(W(\cdot), F(\cdot), \Gamma_\emptyset)$.[19] For Proposition 1(c), we wish to demonstrate that $U^{SP}(\Gamma, \theta; C_p, C_r)$ has

[19]We address the matter of $\Gamma_\emptyset$ (i.e., the constraint set) changing as a result of changes in the exogenous

increasing differences in $(\Gamma; C_p)$ and $(\Gamma; C_r)$ but decreasing differences in $(\theta; C_p)$ and $(\theta; C_r)$. Thus, we cannot infer that (Γ^*, θ^*) is monotone nondecreasing in (C_p, C_r).

For each parameter, we adopt a mix of techniques. To show increasing differences in θ and the parameter, we compare the incremental return of a discrete increase in the parameter at $\theta = r$ and $\theta = p$. This follows the approach taken to show the increasing differences of (Γ, θ) in text.

We proceed differently to show increasing differences in Γ and the parameter. For example, for $W(\cdot)$, we examine $\frac{\partial}{\partial \Gamma}(U^{SP}(\Gamma, \theta; \hat{W}) - U^{SP}(\Gamma, \theta; W))$. If that quantity is weakly positive, increasing differences may be inferred. Note that

$$\frac{\partial}{\partial \Gamma} U^{SP}(\Gamma, \theta; W(\cdot), F(\cdot), C_p(\cdot), C_r(\cdot)) = W'(\Gamma) + F^{-1}(1 - \Gamma) - C'_\theta(\Gamma).$$

NB: We clarify partial orderings using $\succ$ to avoid ambiguity with numerical statements about the parameters, although nothing regarding preferences should be inferred.

1. Partially order the set of functions $\{W(\cdot) | W' \geq 0\}$ with the rule:

$$\hat{W} \succ W \Leftrightarrow \hat{W}' > W', \forall \Gamma.$$

(Γ, W) : $\frac{\partial}{\partial \Gamma}(U^{SP}(\Gamma, \theta; \hat{W}) - U^{SP}(\Gamma, \theta; W)) = \hat{W}'(\Gamma) - W'(\Gamma) \geq 0$, ($>$ for $\Gamma < 1$)

(θ, W) : $U^{SP}(\Gamma, \hat{\theta}; \hat{W}) - U^{SP}(\Gamma, \theta; \hat{W}) - [U^{SP}(\Gamma, \hat{\theta}; W) - U^{SP}(\Gamma, \theta; W)] = 0$

Because status quo utility is certain to increase by less than utility under the optimal policy intervention under a pointwise increase in marginal societal benefit (given the result that $\hat{\Gamma}^* \geq \Gamma^*$, $\hat{W}(\hat{\Gamma}^*) - \hat{W}(\Gamma_\phi) > W(\Gamma^*) - W(\Gamma_\phi)$), if $\Gamma^* \neq \Gamma_\phi$, then $\hat{\Gamma}^* \neq$. That is, if the optimal share choosing $a = 1$ is greater than the status quo, then for all higher W (according to the partial ordering), the optimal share choosing $a = 1$ will be greater than the status quo.

2. Employ the partial ordering given by first-order stochastic dominance to order the set of distributions over valuations, $F(v)$, such that:

$$\hat{F} \succ F \Leftrightarrow \hat{F} < F, \forall v \in \text{int}(\text{supp}(F)).$$

(Γ, F) : $\frac{\partial}{\partial \Gamma}(U^{SP}(\Gamma, \theta; \hat{F}) - U^{SP}(\Gamma, \theta; F)) = \hat{F}^{-1}(1 - \Gamma) - F^{-1}(1 - \Gamma) \geq 0$, ($>$ for $\Gamma < 1$)

elements of the model as relevant; it must be non-decreasing (in the strong set order) in response to changes in other variables.

$(\theta, F): \ U^{SP}(\Gamma, \hat{\theta}; \hat{F}) - U^{SP}(\Gamma, \theta; \hat{F}) - [U^{SP}(\Gamma, \hat{\theta}; F) - U^{SP}(\Gamma, \theta; F)] = 0$

Should a change in a parameter affect the constraint set for the the maximization problem, Theorem 4 from Milgrom & Shannon (1994) provides the condition under which we may still infer monotone comparative statics. Specifically, as long as the constraint set is increasing (in the strong set order) and the strict single crossing property is satisfied in the parameter, we may proceed as before. In this case, the constraint set is $[\Gamma_{\emptyset}, 1] = (1 - F(0), 1)$, which is strictly smaller than $[1 - \hat{F}(0), 1]$ in the strong set ordering.

Utility under the status quo increases under a first-order stochastic increase in the distribution of valuations, potentially faster than under the optimal policy intervention, so it is only possible to conclude $\hat{\Gamma}^* > \Gamma^*$ if it is known that both $\hat{\Gamma}^*, \Gamma^* \neq \Gamma_{\phi}$.

3. Partially order the set of functions $\{C_p(\cdot)|C_p' \leq 0, C_p(1) = \underline{C}_p \geq 0\}$ with the rule:

$$\hat{C}_p \succ C_p \Leftrightarrow \hat{C}_p' < C_p', \forall \Gamma < 1.$$

Note this implies $\hat{C}_p(\Gamma) > \hat{C}_p(\Gamma), \forall \Gamma < 1$.

$(\Gamma, C_p): \ \frac{\partial}{\partial \Gamma}(U^{SP}(\Gamma, \theta; \hat{C}_p) - U^{SP}(\Gamma, \theta; C_p)) = C_p'(\Gamma) - \hat{C}_p'(\Gamma) \geq 0$

$(\theta, C_p): \ U^{SP}(\Gamma, \hat{\theta}; \hat{C}_p) - U^{SP}(\Gamma, \theta; \hat{C}_p) - [U^{SP}(\Gamma, \hat{\theta}; C_p) - U^{SP}(\Gamma, \theta; C_p)] = -\hat{C}_p(\Gamma) + C_p(\Gamma) \leq 0$

4. Partially order the set of functions $\{C_r(\cdot)|C_r' \geq 0, C_r(0) = \underline{C}_r \geq 0\}$ with the rule:

$$\hat{C}_r \succ C_r \Leftrightarrow \hat{C}_r' < C_r', \forall \Gamma > 0.$$

Note this implies $\hat{C}_r(\Gamma) < C_r(\Gamma), \forall \Gamma > 0$.

$(\Gamma, C_r): \ \frac{\partial}{\partial \Gamma}(U^{SP}(\Gamma, \theta; \hat{C}_r) - U^{SP}(\Gamma, \theta; C_r)) = -C_r'(\Gamma) - \hat{C}_r'(\Gamma) \geq 0$

$(\theta, C_r): \ U^{SP}(\Gamma, \hat{\theta}; \hat{C}_r) - U^{SP}(\Gamma, \theta; \hat{C}_r) - [U^{SP}(\Gamma, \hat{\theta}; C_r) - U^{SP}(\Gamma, \theta; C_r)] = -\hat{C}_r(\Gamma) + C_r(\Gamma) \leq 0$

This concludes the proof. ■

B Proofs from Sections 5-6: Majority Preference

B.1 Understanding Preferences across the Population

Lemma 3. *Let* $(P^{**}, R^{**}) := \arg\max_{(P,R)} U^{MV}(P, R)$. *There does not exist a policy more preferred by a majority of individuals than* (P^{**}, R^{**}).

Proof of Lemma 3. $U^i(P_1^{**}, R_1^{**}) - U^i(P_0^{**}, R_0^{**})$ is strictly increasing in v_i. Set $v^{\tilde{i}}$ s.t. $U^{\tilde{i}}(P_1^{**}, R_1^{**}) = U^{\tilde{i}}(P_0^{**}, R_0^{**})$. It must be that $\forall i$ s.t. $v^i > v^{\tilde{i}}$, $U^{\tilde{i}}(P_1^{**}, R_1^{**}) > U^{\tilde{i}}(P_0^{**}, R_0^{**})$.

From the monotonicity of the preference relation with respect to v^i and an application of the median voter theorem, we conclude that the majority preference relation is equivalent to the preference relation of the individual with the median valuation. It is also the case that if the median voter prefers the lack of a policy intervention to the better of (P_1^{**}, R_1^{**}) and (P_0^{**}, R_0^{**}), so will all those taking the same action under $(P, R) = (0, 0)$. ■

Lemma 4. *All members of the population prefer the use of either an incentive or a disincentive policy – but not both – to achieve any given level of compliance.*

Proof of Lemma 4. Let $P = \varphi X$ and $R = (1-\varphi)X$, with $\varphi \in [0, 1]$. Then consider:

$$U^i(X, \varphi) = \begin{cases} W(1 - F(-X)) + F(-X)X - \mathbb{I}_{\varphi>0}C_p(F(-X)) + v^i - \mathbb{I}_{\varphi<1}C_r(1 - F(-X)) + v^i \\ \hfill \text{if } v^i \geq -X \\ W(1 - F(-X)) - (1 - F(-X))X - \mathbb{I}_{\varphi>0}C_p(F(-X)) - \mathbb{I}_{\varphi<1}C_r(1 - F(-X)) \\ \hfill \text{if } v^i < -X \end{cases} \tag{6}$$

In either case, the only terms that depend on φ are the cost terms. Any share choosing $1 - F(-X)$ could be induced with only one policy, and this would reduce the cost. As above, this result holds (albeit less starkly) even if the cost of each type of policy rises in the size of punishment or reward, not just in the measure of the population to which it is applied. ■

B.2 Comparative statics of majority-preferred policy

The office-motivated politician, seeks to maximize the decisive voter's utility by choosing a level of compliance among the population (Γ) and a type of policy (θ). The politician must, however, take into account whether the decisive voter will herself choose $a = 1$ *ex post*, and this may be treated as a third choice variable. As such, it is useful to rewrite the utility function of the decisive voter in terms of the (Γ, θ) formulation, recalling that $-X = F^{-1}(1 - \Gamma)$, where $X = P + R$, and that the decisive voter will in fact choose $a^{MV} = 1$ when $v^{MV} \geq -X \Leftrightarrow \Gamma > \frac{1}{2}$.

$$U^{MV}(\Gamma, \theta, a^{MV}) = \begin{cases} U_{1,\theta}^{MV}(\Gamma) = W(\Gamma) - (1 - \Gamma)F^{-1}(1 - \Gamma) - C_\theta(\Gamma) + v^{MV} & \text{if } a^{MV} = 1 \\ U_{0,\theta}^{MV}(\Gamma) = W(\Gamma) + \Gamma F^{-1}(1 - \Gamma) - C_\theta(\Gamma) & \text{if } a^{MV} = 0 \end{cases} \tag{7}$$

Our primary interest is in comparing the majority-preferred policy intervention to the utilitarian social planner's optimal policy intervention. In service of this, however, we will wish to demonstrate that U^{MV} has increasing differences in all pairs of choice variables: not only (Γ, θ) but also (Γ, a^{MV}) and (θ, a^{MV}). If this can be shown, then if U^{MV} has increasing differences in an exogenous variable and each choice variable, we may draw conclusions to the effect that an increase in the exogenous parameter makes higher compliance (indeed, majority compliance) and the use of punishments more favorable. We may be sure the compliance of the decisive voter complements the choice of size and type of policy intervention, and we may characterize the circumstances in which the harmful action $a = 0$ might be encouraged. Because the pairwise complementarity ensures that indirect effects only enhance direct effects, we may be satisfied that the conclusions drawn from such analysis are particularly robust.

Demonstrating increasing differences between the pair $(\Gamma, \theta), \theta \in \{p, r\}$[20] proceeds exactly as did the inequality in 4. Increasing differences between the pair (Γ, a^{MV}) is indeed an implication of the main result below. Finally, there is no direct relationship between (θ, a^{MV}). To provide an example of an exogenous change that leads the endogenous variables to weakly increase, we seek increasing differences with respect to pointwise increases in the marginal benefit, W. These results appear as Proposition 3, nested within the proof of Proposition 2' – the result that provides the comparison between the the majority-preferred and utilitarian-optimal policies.

Proposition 2'. *Let (Γ^*, θ^*) be the social-welfare maximizing level of compliance and type of policy, and let $(\Gamma^{**}, \theta^{**})$ be the policy (inducing $a = 1$) that maximizes the decisive voter's utility, i.e., the majority-preferred winning policy if limited to $\Gamma \in [\Gamma_\emptyset, 1] \Leftrightarrow P, R > 0$. Suppose both policies entail active interventions, such that $\theta^*, \theta^{**} \neq \phi$.*

A majority neither punishes itself for non-compliance nor rewards a minority of compliers sufficiently to achieve the optimal level of compliance. Formally, if $\Gamma < 1/2 \Leftrightarrow \alpha = 0$, such that a majority of the population chooses $a = 0$, and $\theta \neq \phi$, then $\Gamma^{**} < \Gamma^*$.

A majority either rewards itself or punishes the minority excessively, so as to achieve greater than the optimal level of compliance. Formally, if $\Gamma > 1/2 \Leftrightarrow \alpha = 0$, such that a majority of the population chooses $a = 0$, and $\theta \neq \phi$, then $\Gamma^{**} > \Gamma^*$.

Conditions that increase the attractiveness of a higher share of the population choosing $a = 1$, e.g., increases in the marginal benefit of compliance, indirectly favor the outcomes in which a majority of compliers imposes a larger-than-efficient disincentive on the minority of non-compliers, or in which a majority of non-compliers institutes a smaller-than-efficient incentive for the minority of compliers.

[20] Recall that we adopt the ordering $p > r$.

Proof of Proposition 2'. Consider the following series of inequalities:

$$\begin{aligned}
\frac{\partial U^{MV}_{1,\theta}}{\partial \Gamma} &= W' + \frac{1-\Gamma}{f(F^{-1}(1-\Gamma))} + F^{-1}(1-\Gamma) - C'_\theta \\
&\geq \\
\frac{\partial U^{SP}_{\theta}}{\partial \Gamma} &= W' + F^{-1}(1-\Gamma) - C'_\theta \qquad , \forall \Gamma \in [\Gamma_\emptyset, 1]. \\
&\geq \\
\frac{\partial U^{MV}_{0,\theta}}{\partial \Gamma} &= W' - \frac{\Gamma}{f(F^{-1}(1-\Gamma))} + F^{-1}(1-\Gamma) - C'_\theta
\end{aligned}$$

Viewed in the context of Proposition 1(a), were we to define $\hat{W}' = W' + \frac{1-\Gamma}{f(1-\Gamma)}$ and $\hat{\hat{W}}' = W' - \frac{\Gamma}{f(1-\Gamma)}$, we would find $\hat{W}' \geq W'$ and $W' \geq \hat{\hat{W}}'$ pointwise and could draw the same conclusion regarding increasing differences in (Γ, α).

Applying Proposition 1 to $U^{MV}_{0,\theta}$ and $U^{MV}_{1,\theta}$, the results regarding $\Gamma^{**} \gtrless \Gamma^*$ follow immediately, and the indirect effect of increasing Γ is that $\theta^{**} \geq \theta^*$.

Proposition 3. *Let the majority-preferred winning policy, consisting of a level of compliance, $\Gamma \in [0,1]$, and type of policy, $\theta \in \{p, r, \phi\}$, under the functions W, F, C_p, and C_r be given by $(\Gamma^{**}, \theta^{**})$. Further, let the decisive voter's decision to comply or not under $(\Gamma^{**}, \theta^{**})$, $a^{MV}(\Gamma^{**}, \theta^{**}) \in \{0, 1\}$, be given by α^{**}.*

(a) Let $(\hat{\Gamma}^{**}, \hat{\theta}^{**})$ be the majority-preferred winning policy under $\hat{W}$ (holding the other functions at the values above) and $\hat{\alpha}^{**}$ be the action choice of a majority of the population.

If $\hat{W} \geq W'$, such that the marginal benefit of compliance under $\hat{W}$ is weakly higher than under W for all levels of compliance, then $\hat{\Gamma}^{**} \geq \Gamma^{**}$ and $\hat{\alpha}^{**} \geq \alpha^{**}$. If $\Gamma^{**} > \Gamma_\emptyset$, then $\hat{\theta}^{**} \geq \theta^{**}$.

Proof of Proposition 3. We need only show increasing differences in $\{\Gamma, \theta\} \times \{W, F\}$, with W ordered by pointwise larger first derivatives and F ordered by first-order stochastic dominance. Recall that α denotes the *ex post* compliance of the decisive voter, and thus a majority of the population.

1. $\hat{W} \succ W \Rightarrow \hat{W}' > W', \forall \Gamma \in [0,1]$

$(\Gamma, W):\ \frac{\partial}{\partial \Gamma}[U^{MV}(\Gamma, \theta; \hat{W}) - U^{MV}(\Gamma, \theta; W)] = \hat{W}' - W' \geq 0$

$(\theta, W):\ U^{MV}(\Gamma, \hat{\theta}; \hat{W}) - U^{MV}(\Gamma, \theta; \hat{W}) - [U^{MV}(\Gamma, \hat{\theta}; W) - U^{MV}(\Gamma, \theta; W)] = 0$

Finally, α^{**} is an increasing function of Γ^{**}. ■

Finally, the increasing differences among the choice variables imply $\alpha = 1$ is associated (mechanically) with higher Γ, which indirectly makes punishments more attractive relative to rewards, leading to an association between larger-than-optimal interventions and the use of punishments and smaller-than-optimal interventions and the use of rewards. Conditions that directly affect the optimal Γ push α and θ up or down together. ■

Corollary 1'. *Let the majority-preferred winning policy, consisting of a level of compliance, $\Gamma \in [0,1]$, and type of policy, $\theta \in \{\phi, p, r\}$, under the functions W, F, C_p, and C_r be given by $(\Gamma^{**}, \theta^{**})$.*

(a) Let $(\hat{\Gamma}^{**}, \hat{\theta}^{**})$ be the majority-preferred winning policy under $\hat{W}$ (holding the other functions at the values above).

If $\hat{W}' \geq W'$, such that the marginal benefit of compliance under $\hat{W}$ is weakly higher than under W for all levels of compliance, and if $\hat{\Gamma}^{**} < \Gamma_{\emptyset}$, then $\Gamma^{**} < \hat{\Gamma}^{**} < \Gamma_{\emptyset}$, and $\theta^{**} \leq \hat{\theta}^{**}$.

Proof of Corollary 1'. Follows directly from Propositions 1-2. ■

C Proofs from Section 7: Introducing Unaffected Subpopulations

Lemma 6. *A member of the unaffected subpopulation's most-preferred policy does not include both types of policy, i.e., it is never the case that $P \neq 0$ and $R \neq 0$.*

Proof of Lemma 6. Let $P = \varphi X$ and $R = (1-\varphi)X$, with $\varphi \in [0,1]$. The size of the unaffected subpopulation is $\lambda \in (0,1)$. Then consider:

$$\begin{aligned}
U^{\ell}(X, \varphi; \lambda) &= W((1-\lambda)(1-F(-X))) \\
&\quad -(1-\lambda)(1-\varphi)X(1-F(-X)) - \mathbb{I}_{\varphi<1}C_r((1-\lambda)(1-F(-X))) \\
&\quad +(1-\lambda)\varphi X F(-X) - \mathbb{I}_{\varphi>0}C_p((1-\lambda)F(-X)) \\
&= W((1-\lambda)(1-F(-X))) \\
&\quad -(1-\lambda)X(\varphi-(1-F)) \\
&\quad -\mathbb{I}_{\varphi<1}C_r((1-\lambda)(1-F(-X))) - \mathbb{I}_{\varphi>0}C_p((1-\lambda)F(-X))
\end{aligned}$$

Given some share of the population choosing $a = 1$, what is the best value of φ? If $X - C_p(F(-X)) > -C_r(1-F(-X))$, then φ should be set to 1, i.e., only P used, and vice versa. If equal, one would not want to double up on the cost, but only use one or the other. Indeed, the left-hand side is increasing in X, while the right-hand side is decreasing in X. As such, at high shares of the population choosing $a = 1$, P is the better policy instrument, and again vice versa. ■

Corollary 2' *Assume that $\lambda \geq \frac{1}{2}$, such that a majority of the population will receive neither incentive nor disincentive under a policy intervention.*

Let $(\Gamma^{\ell*}_{1,p}, p)$ be the policy that maximizes $W((1-\lambda)\Gamma) - (1-\lambda)(1-\Gamma)F^{-1}(1-\Gamma) - C_p((1-\lambda)\Gamma)$ and $(\Gamma^{\ell*}_{0,r}, r)$ be the policy that maximizes $W((1-\lambda)\Gamma) + (1-\lambda)\Gamma F^{-1}(1-\Gamma) - C_r((1-\lambda)\Gamma)$. It is the case that

$\Gamma^{\ell*}_{1,p} > \Gamma^{\ell*}_{0,r}$.

Let the majority-preferred winning policy under the functions W, F, C_p, and C_r be given by $(\Gamma^{\ell*}, \theta^{\ell*})$. It is the case that $(\Gamma^{\ell*}, \theta^{\ell*}) \in \{(\Gamma^{\ell*}_{1,p}, p), (\Gamma_{\emptyset}, \phi), (\Gamma^{\ell*}_{0,r}, r)\}$.

(a) *Let $(\hat{\Gamma}^{\ell*}, \hat{\theta}^{\ell*})$ be the majority-preferred winning policy under $\hat{W}$.*

It must be that $(\hat{\Gamma}^{\ell*}, \hat{\theta}^{\ell*}) \in \{(\Gamma^{\ell*}_{1,p}, p), (\Gamma_{\emptyset}, \phi), (\Gamma^{\ell*}_{0,r}, r)\}$.

If $\hat{W} \geq W'$, such that the marginal benefit of compliance under $\hat{W}$ is weakly higher than under W for all levels of compliance, and if $\hat{\theta}^{\ell*}, \theta^{\ell*} \neq \phi$, then $\hat{\Gamma}^{\ell*} \geq \Gamma^{\ell*}$.

Proof of Corollary 2'. The arguments in text establish that the majority-preferred policy intervention will be the more preferred of the complier-preferred disincentive and the non-complier-preferred incentive. Moreover, as the $(1-\lambda)$ drops out of the first-order condition, these policies coincide with the majority-preferred policies in the prior section. The comparative statics of the optimal policy intervention then follow immediately from previous results.

■