Incentives or Disincentives?*

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Abstract

When government seeks to induce a behavior among the population it governs, it may use either incentive policies to reward those that comply with the desired behavior or disincentive policies to punish those who do not comply. We ask which type of policy a majority of the population will prefer, and how it compares to the policy a social planner would choose. If the costs of administering a policy increase in the share of the population receiving the reward or punishment, then raising the size of a reward, which increases compliance, increases administrative costs. Raising the size of a punishment, which decreases noncompliance, lowers administrative costs. As such, using punishments (vis-à-vis rewards) is complementary to higher levels of compliance, with a majority tending to prefer larger punishments (and smaller rewards) than the social planner. We ground the results in a variety of policy-relevant examples, particularly questions in food policy.

Keywords: Incentives, disincentives, redistribution, food policy

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1 Introduction

Surveying the landscape of public policy, we find policymakers employing incentives and disincentives both across and within a wide range of policy domains. The "individual mandate" to procure health insurance for oneself and the accompanying threat of fines if one was found in violation were central to the Affordable Care Act. A key feature of the proposed replacement is a program of subsidies to encourage individuals to purchase health insurance. In the realm of environmental policy, polluting activities are often discouraged through taxes, while Cash for Clunkers initiatives reward the retirement of less efficient vehicles or subsidize the purchase of more efficient vehicles. Even national education policy has featured both disincentive- and incentive-based policies in recent years with No Child Left Behind and Race to the Top, respectively (Howell 2004, Howell & Magazinnik 2017).

These examples suggest, and it is theoretically plausible, that a policymaker wishing to influence behavior in a population may turn to either rewards or punishments. In what circumstances should individuals that take a desired behavior be rewarded, and in which cases should individuals that fail to comply with a desired behavior receive punishment? How does the normative answer to these questions compare to the positive answer? In particular, when accounting for the redistributive implications of such policies, how does the politically viable policy intervention compare to the policy intervention that maximizes social well being? While much policy aims to promote positive externalities or reduce negative externalities, under what conditions will we observe socially beneficial behaviors discouraged, or socially harmful behaviors encouraged?

This paper approaches these questions by modeling a simple setting in which each member of a population chooses one of two actions. The central question of this paper is not which of these two actions ought to be encouraged. It is known which is the more socially desirable action. Rather, we wish to know which type of policy – incentive or disincentive – a public-interested social planner would use to encourage the socially desirable action and which type of policy a majority of the population would support. This provides a sense for the policy outcome of a democratic process and the ways in which it may fail to align with the population's welfare.

In both contexts, we are interested in the type of policy, i.e., incentive or disincentive, as well as the size of the intervention, i.e., how big is the reward/punishment, how much compliance does it induce? Our aim is to understand how these answers change as a function of the rate at which benefit accrues to society from its members taking the socially desirable action, the distribution of preferences over taking that action, and the costs of administering each type of policy intervention. While the costs entailed in government intervention always deserve attention, as they must not outweigh the benefits, the costs of administering policy interventions play a much larger role here.

Specifically, we highlight an inherent difference in the way that costs accrue from incentive and disincentive policies and the implications of this difference for which type of intervention policymakers should, and will, employ. We suppose that the administrative costs associated with policies grow in the share of the population to which they are applied. *Further, rewards must be given to all those who comply, while punishments must be given to all those who do not, and they must be given at the same level.* Increasing the size of a reward induces greater compliance, which in turn increases the share of the population who must receive the reward, applying upward pressure on administrative costs. Increasing the size of a punishment also induces greater compliance, but this reduces the share of the population who must receive the punishment, applying downward pressure on administrative costs. This suggests a complementarity between achieving higher levels of compliance and the use of punishments rather than rewards.

We motivate some of the modeling choices and ground the results with several applications from the domain of food policy in the United States. These include the Conservation Reserve Program, run by the Farm Services Administration, which incentivizes farmers to lake land out of agricultural production,[1] the infamous "sugary drink taxes,"[2], increasing the value of food stamps when they are used on fruits and vegetables, and the farmer-borne costs entailed in organic certification. In many of these cases, policymakers – and citizens in large part – agree there is a harm not internalized by members of the population. In the first, it is the overuse of land and overproduction of certain crops. In the second and third, it is the adverse effects of poor health that ripple across the U.S. economy. In each case, policymakers wish to encourage individuals to take a desired behavior, be it more judicious land management and environmental stewardship or healthier consumption choices. This paper asks why incentives are used in some of the policies while disincentives are used in others. In so doing, it also sheds light on policies like the fourth example, in which a socially beneficial behavior seems to be taxed.

After placing this paper in the context of related literatures, we clarify our modeling of the policymaking environment, which enables us to address the normative point of view of the social planner. We then turn to the political economy of incentives and disincentives. After accounting for redistri-

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

[2] 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`.

bution, we inquire as to the pressure that popular support might exert on the choice of policy, how this choice compares to the policy that a social planner would have chosen, and some of the vagaries of the majority-preferred policy, such as the possibility of policies that discourage beneficial behavior. We instantiate many of the concepts and claims in the context of U.S. food policy before concluding with a brief review of the insights uncovered herein and ideas for future work on the use of incentives and disincentives.

2 Related Literature

The goal of this paper may be summarized as developing an institutional account of the differences between incentives and disincentives. While behavioralists across the social sciences have for some time appreciated differences in the way that incentives and disincentives work (Kaplow & Shavell 2007, Benabou & Tirole 2011), institutions-centered analyses often tacitly assume the two types of policy to be functionally equivalent. Further, the decision to use an incentive or a disincentive, either from a normative or positive perspective, has not been addressed in a decidedly political context.

Institutional analyses in political science 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). When it comes to the implementation of policy decisions, even Pressman & Wildavsky's (1984) landmark study focuses on the target of policies, rather than the choice of instrument with which to pursue a given target.

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 their 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, we must begin more agnostically, framing the two approaches as similarly as possible. Further, without formally modeling the salient features common across policy domains, it is difficult to readily extend the discussion to the policy that would emerge from the democratic process, much less to compare these predictions to the socially optimal policy.

The economics literature has approached questions of punishment or reward from a number of angles, but few with any political context. For instance, principal-agent models deal directly with behavior change through incentives and disincentives (Holmstrom 1979), but the principals are profit-seeking rather than public-interested or office-motivated. Further, because much of the moral hazard literature consider a single agent (Banks & Sundaram 1998, p. 299), this leaves no room for a true choice between incentives and disincentives. As an example, Dal Bo, Dal Bo & Di Tella (2006) study the use of bribes and/or threats (physical and political) by a group looking to gain influence over government officials. Because the politician will either comply or not, the group will never have to undertake both costly endeavors and may put both on the table. This is no longer the case when applying incentives or disincentives to an entire population.

The economic theory of regulation, inaugurated by Stigler (1971) and Posner (1974), sought to replace the long-standing assumption that regulation served the public interest with the understanding that regulation was the outcome of strategic interaction among competing interest groups (Peltzman 1989, Shleifer 2005). In doing so, it shifted attention away from the evaluation of alternative policy instruments. While Becker's (1983, 1985) pathbreaking work on interest groups does consider taxes and subsidies, they are purely redistributive, separated from any policy seeking to affect behavior.

The literature on public enforcement is almost entirely concerned with the deterrence of undesirable actions through punishment (see Polinsky & Shavell (2000) for a thorough review of the literature). Again, a notable exception comes from Becker (1968), who does consider the use of rewards, as well as punishments, and who appreciates the way that the size and scale of policies affect costs differently in the two types of policies. He stops short, however, of asking why desirable behavior is sometimes induced with incentives and at other times with disincentives, either normatively or positively.

Beginning with Coase (1960), the theory of torts has long appreciated the symmetry underlying the assignment of liability, asking whether to lay fault with the injurer (e.g. a firm) or the injured (e.g. a consumer) in the event of an accident (Calabresi & Melamed 1972, Miceli 2004).[3] The institutional choice problem in the study of torts is to choose the least-cost avoider (Posner 2005). In our setting, the social planner seeks to minimize the administrative costs entailed in carrying out the policy, and she has no action available to her analogous to precaution in the torts setting, and nothing akin to

[3] Indeed, our question may be placed in the Coasian framework. Should the government retain "property rights" over a domain and exact payment from those that choose $a = 0$, or should the government cede these rights and offer to pay any individuals who choose $a = 1$?

transactions costs in determining/enforcing the optimal policy to worry about.

A small corner of the welfare economics literature does inform much of the approach we take below. Writing in the Pigouvian tradition, Weitzman (1974) asks whether price or quantity policies are preferable. This and subsequent work limit the analysis of price policies to taxes, leaving aside the possibility of subsidies (Pizer 1997, Grodecka & Kuralbayeva 2015). Furthermore, the difference between price and quantity policies in these papers hinges on uncertainty about the benefits and costs of regulation, while in the model below we rely only on the heterogeneity of actors within a population. However, the philosophy with which Weitzman approaches his analysis is precisely that with which we approach ours:

> ...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)

3 Modeling the Policy-Making Context

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 let i's *ex ante* valuation for taking the desired action as v^i (i.e., in the absence of any incentives or disincentives).[4] We assume the valuations are 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 comply with the desired behavior without any further inducement. Indeed, we assume $\underline{v} < 0 < \overline{v}$, such that there are *ex ante* compliers and non-compliers in the population.[5]

When members of the population choose $a = 1$ instead of $a = 0$, it imparts social benefit (or, equivalently, reduces social harm). As such the social planner – a public-interested policymaker – would only consider policies that encourage $a = 1$ or $a = 0$. In principle, however, a policy may

[4]This term captures the net benefit of taking $a = 1$ or $a = 0$. Indeed, set $u^i(0) = 0$, so $\forall i, v^i = u^i(1)$.

[5]The concept of heterogenous valuations is particularly salient for incentives or disincentives to grow certain crops. The border between growing regions ought not to be thought of as entirely rigid nor entirely malleable. Between two regions, farmers can switch between crops more easily than those firmly inside a given growing region. How far into an area the margin is found depends on the size of the policy intervention.

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 $a = 1$. We focus first on the social planner's optimal policy, though, because it serves as a benchmark for the subsequent analyses and is interesting in its own right as a study of correcting market failure. Further, we consider monetary incentives and disincentives, namely subsidies and taxes, though the analysis is amenable to other kinds of incentive and disincentive policies.[6]

A social planner wishing to encourage citizens to take action $a = 1$ rather than $a = 0$ may reward those who comply, punish those who do not, both, or neither. To capture the constraints of policymaking, we 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.[7] We proceed at first as though all members of the population are subject to the policy, i.e., that we cannot distinguish a subpopulation of interest to whom the policy applies and the remainder of the population to whom it does not. We later consider the presence of an "unaffected" subpopulation. We 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 so as to abstract from behavioral concerns, and we assume 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 complying plus any rewards offered is at least as large as the utility she receives from choosing $a = 0$ minus any threatened punishments, i.e., $v_i + R \geq -P$. We then have the following result regarding *ex post* compliance.

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

The social planner takes into account any externalities from compliance (positive from choosing $a = 1$ and/or negative from choosing $a = 0$), the utility that members of the population derive from their chosen action, and the deadweight costs of administering policies. Let the function $W : [0, 1] \rightarrow \mathbb{R}$ represent the external benefit to society from a fraction of the population choosing $a = 1$. We assume

[6] We use taxes and fines interchangeably, as in "carbon tax," where the tax is a penalty, not redistributive in purpose.

[7] Consider the Environmental Quality Incentives Program (EQIP). This is a reward-based initiative encouraging a variety of sustainable practices in agriculture. A central problem of enforcement of this program has been larger operations receiving funds for practices they would have already undertaken, and which do not represent additional efforts taken towards sustainability (Wilde 2013, pp. 50-51). For example, large-scale animal feeding operations have applied and received funding for setting up waste storage lagoons – a necessary endeavor for these facilities and one that need not have been incentivized. Yet that is the nature of rewards. They must be applied to all who comply and are in the eligible population.
https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/eqip/ accessed January 2017.

that $W(\cdot)$ is continuously differentiable, with $W' > 0$. We do not consider the possibility that members of a population impose heterogeneous external costs and/or benefits through their actions.

The internalized effects of individuals' actions on their utility across the population are given by the "sum" of the valuations of all those who comply by choosing $a = 1$. As our population is a continuum, we write $\int_{-R-P}^{\bar{v}} v f(v) dv$, where $\{i | v^i \in [-R-P, 0)\}$ constitutes the set of *ex post* compliers that would not have complied without the inducement of any incentives or disincentives. Recall that v^i accounts for the benefits and costs of compliance 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. This would be the distortionary effect of a policy intervention, as typically conceived of in the welfare economics literature.

Total rewards distributed are of the sum $R \cdot [1 - F(-R-P)]$, as the entire measure 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. Transfers have no net effect on the social planner's utility. Total punishments equal $P \cdot F(-R-P)$, as the measure of those choosing $a = 0$ 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, so it is also not taken into account by the social planner.

Such transfers, however, are not administered without costs. We account for the gain or loss from transfers in our formulation of the deadweight costs to policy. Let $C_p : [0, 1] \to \mathbb{R}$ and $C_r : [0, 1] \to \mathbb{R}$ be functions giving the administrative cost incurred to achieve a given level of compliance via disincentives and incentives, respectively. Note that $C_p(1 - F) > 0$ and $C_r(1 - F) > 0$. 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), suppose $C_p'(1 - F) < 0$ and $C_r'(1 - F) > 0$.[8]

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. It is likely, though, that certain forms of rewards, such as tax credits, require a smaller administrative apparatus

[8] It is likely that administrative costs also increase in the size of the reward and/or punishment, as well. The formulation above provides the most straightforward analytical approach to drawing out the central insights of the model, however, so we proceed as though administrative costs of a policy depend only on the measure of individuals to whom that policy is applied. Importantly, allowing administrative costs to increase in the size of the policy as well as in the share of the population recieving the reward or punishment does not alter any of the substantive conclusions presented below.

than punishments. In any case, we may wish to let the fixed costs of the two types of policies differ from one another. To allow for this flexibility, let $C_p(1) \geq 0$ and $C_r(0) \geq 0$.

Example The figures illustrating key results that appear throughout the paper all employ the same simple functional forms, which we specify here as examples to ground the descriptions above of the components of the model.

Letting $v^i \sim U(\underline{v}, \overline{v})$, then $F(v) = \frac{v-\underline{v}}{\overline{v}-\underline{v}}$, and where $a < 0 < b$. *ex ante* compliance is then $1 - F(0) = \frac{\overline{v}}{\overline{v}-\underline{v}} \in (0, 1)$. The effect on individuals' utility of changing their behavior is given by $\int_{-R-P}^{\overline{v}} vf(v)dv = \frac{\overline{v}^2-(-R-P)^2}{2(\overline{v}-\underline{v})}$ Further, suppose:

$$
\begin{aligned}
W(1 - F(-R - P)) &= g \cdot [1 - F(-R - P)] = g \cdot \left(\frac{\overline{v} + R + P}{\overline{v} - \underline{v}} \right), \; g > 0 \\
C_p(1 - F(-R - P)) &= C_p \cdot F(-R - P) = C_p \cdot \frac{-R - P - \underline{v}}{\overline{v} - \underline{v}}, \; C_p > 0 \\
C_r(1 - F(-R - P)) &= C_r \cdot [1 - F(-R - P)] = C_r \cdot \frac{\overline{v} + R + P}{\overline{v} - \underline{v}}, \; C_r > 0
\end{aligned}
$$

In these examples, there is no fixed administrative cost of either type of policy, i.e., $C_r(0) = C_p(1) = 0$.

4 The Social Planner's Optimal Policy

The social planner – a public-interested policymaker – thus faces the following problem:

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

subject to the constraint that this be greater than social welfare under the status quo, which is given by $W(1 - F(0)) + \int_0^{\overline{v}} vf(v)dv$.

As a preliminary step in understanding the social planner's optimal type and size of policy, we first show that it is never optimal to use both incentives and disincentives to encourage the same behavior. This result stems from the opposing directions in which the administrative costs of punishment and reward policies respond to increases in compliance with the desired behavior among the population. The result reduces the social planner's problem to comparing the optimal punishment-based policy and the optimal reward-based policy. This significantly simplifies the ensuing analysis and is itself an interesting insight.

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

The proof, which may be found in Section A.1 of the Appendix, builds upon the administrative costs of punishments decrease in compliance with $a = 1$ achieved, while the administrative costs of rewards increase in compliance. If there exists a level of compliance with $a = 1$, say $1 - \tilde{F}$, at which $C_r(1-\tilde{F}) = C_p(1-\tilde{F})$, then for all $1-F > 1-\tilde{F}$, punishments are the cheaper method of encouraging $a = 1$, while for all $1-F < 1-\tilde{F}$, rewards are the cheaper method. To achieve the level of compliance $1 - \tilde{F}$, the social planner would be indifferent among the two types of policies but would want to use only incentives or only disincentives, so as not to double up on costs. Hence, the least-cost approach to achieving any level of compliance never entails using both types of policies in concert.[9]

Lemma 1 allows us to narrow our focus to the cases in which the policymaker will use only punishments or only rewards, if she intervenes at all. The social planner's 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, then compare social welfare under P^* and R^* to find the optimal type (and size) of policy.

Equations 2 and 3 characterize the solutions to the problems of choosing an optimal P and an optimal R as individual policies. The social planner maximizes $W(1-F(-P)) + \int_{-P}^{\bar{v}} vf(f)dv - C_p(1-F(-P))$ with respect to P to find the best choice for the size of punishment to obtain:

$$[P] : W'(1-F) \cdot f - P^* \cdot f = C_p'(1-F) \cdot f. \quad (2)$$

The social planner maximizes $W(1-F(-R)) + \int_{-R}^{\bar{v}} vf(v)dv - C_p(1-F(-R))$ with respect to R to find the best choice for the size of reward to obtain:

$$[R] : W'(1-F) \cdot f - R^* \cdot f = C_r'(1-F) \cdot f. \quad (3)$$

These two equations implicitly characterize the best choice of P and the best choice of R, were the policymaker restricted to each type of policy, respectively. Under the limited assumptions we have deployed, however, do the equations indeed characterize maxima? Can we guarantee uniqueness? What is needed for existence? Will the social planner prefer P^* or R^*? Rather than invoke additional assumptions to ensure uniqueness or even the existence of interior solutions given by Equations 2 and 3, and to characterize social planner's most preferred policy, we employ results from the theory of

[9]As remarked on in the Appendix, this result is robust to expanding the influences on administrative cost to include the size of the policy itself (i.e., P, R), not just the measure of individuals to whom a policy is applied.

monotone comparative statics.

To facilitate this approach, we reframe the social planner's decision as jointly determining the optimal level of compliance and optimal type of policy. The type of policy is taken to be one choice variable, and the level of *ex post* compliance achieved is taken to be the other.[10] With regards to the type of policy, we will be interested in the attractiveness of using punishments relative to the attractiveness of using rewards to achieve a given level of *ex post* compliance. We treat the decision to deploy an active policy intervention or to remain at status quo levels of compliance ($P, R = 0$) as a subsequent decision, in which the optimal policy intervention is compared to the status quo.

Definition 1 (Optimal Policy Intervention)**.** *The social planner's most-preferred policy intervention, characterized by an optimal level of compliance and an optimal type of policy that together specify* $P^* > 0$ *or* $R^* > 0$*.*

We seek to derive results about the way in which the optimal choice of type and size of policy changes 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* level of compliance and the use of disincentives (as opposed to incentives) are complements. This is a direct result of the asymmetric way in which administrative costs accrue under each incentive and disincentive policies.[11]

Lemma 2. *An increase in the level of compliance,* $1-F$*, 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 compliance 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, where all increases/decreases are weak and where we use the ordering $p > r$. An exogenous change that increased the optimal level of compliance would make the use of punishments increasingly attractive relative to the use of rewards, though rewards may still be the optimal policy. This approach ensures that any indirect effects that occur among the choice variables reenforce the direct effect of the exogenous variable on the optimal policy. Only if a change in an exogenous variable leads to an increase in one choice variable but a decrease in the other will we be unable to be sure of the overall effect of the change in the variable on the optimal policy.

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

[11]Equation 7 and the surrounding discussion in Appendix A.1 suffice as a proof of the assertion.

The parameters of interest are the functions $W(\cdot)$, $F(\cdot)$, $C_p(\cdot)$, and $C_r(\cdot)$. We look for complementarity between each exogenous element and the choice variables. Proposition 1 makes clear that such conclusions are possible for some parameters but not with others. We split the Proposition into parts to facilitate the exposition and explanation of the result for each parameter.[12]

Proposition 1 (a)**.** *As the added value to society from additional compliance with $a = 1$ rather than $a = 0$ increases at all levels of compliance: the level of compliance in the optimal policy intervention increases; the administrative cost of using disincentives to achieve the optimal level of compliance decreases, while the cost of using incentives increases; and 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 – conceived of either as the societal benefit that accrues from greater compliance with $a = 1$ and/or the social cost from individuals choosing $a = 0$. Increasing the benefit of additional compliance with $a = 1$ at all levels of compliance (i.e., for all $1 - F \in [0, 1]$) leads the social planner to want higher *ex post* levels of compliance. Even though there is no direct effect on the optimal type of policy, because of the complementarity between higher levels of *ex post* compliance and the use of punishments rather than rewards, the change increases the attractiveness of using disincentives relative to using incentives. While increasing the benefit of additional compliance with $a = 1$ 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.

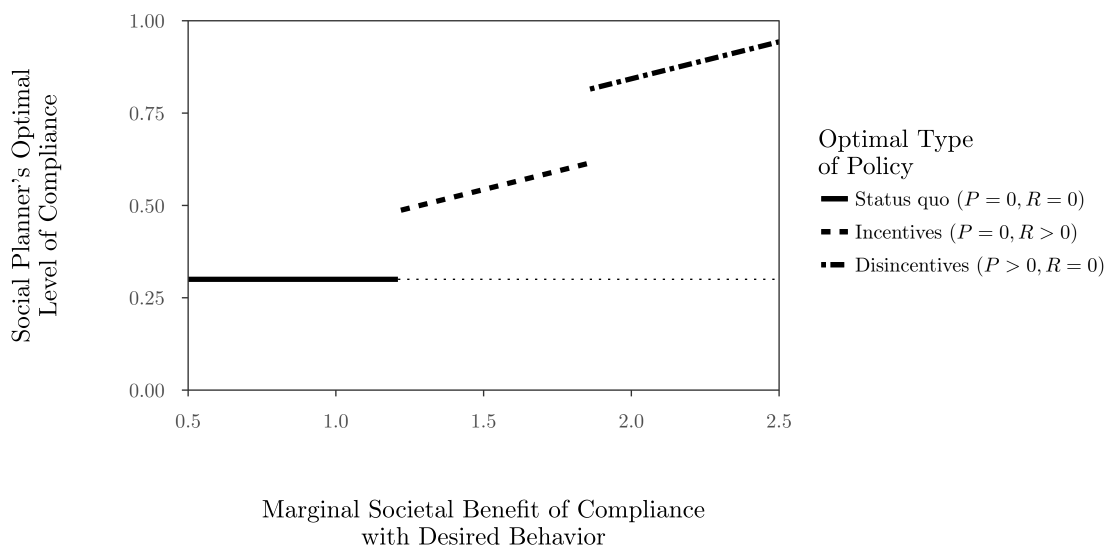
Figure 1 depicts the comparative statics from part (a). As the marginal societal benefit from additional compliance increases (at all levels of compliance), the optimal level of compliance is weakly increasing. Accordingly, the optimal type of policy moves from rewards to punishments. Further, once a policy intervention is optimal (vis-à-vis the status quo), policy intervention remains optimal as additional compliance yields even higher marginal societal benefit.

A useful characterization of the result, albeit not entirely precise, goes as follows. Policy domains in which a small increase in the share of the population choosing $a = 1$ relative to the status quo yields large but rapidly diminishing increases in societal benefit (or reduction of societal cost) favor the use of rewards. Policy domains in which small levels of non-compliance with $a = 1$ bear high societal cost (or forgo large societal benefits) favor the use of punishments.

Consider the rewards in the form of monopolistic market power that are granted to patent and

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

Figure 1: The effect of increasing the marginal benefit to society of compliance on the optimal level of compliance and type of policy



Notes: The dotted line represents the status quo level of compliance. As per the functional forms given in the example above, g is the marginal societal benefit, or W' in the notation of the model.

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 we 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), small levels of non-compliance achieved with a (possibly large) punishment often most efficiently attain the external benefit of compliance without incurring excessive administrative costs.

This insight comprises the most direct answer to the normative aspect of the question motivating this paper, namely, when should we use an incentive rather than a disincentive to induce a desired behavior? A policy domain characterized by the goal of near elimination of a given market failure across the population is likely best served by a punishment policy, as this is the cheapest type of policy to administer for high levels of compliance. A policy domain characterized by the goal of inducing a small level of compliance, perhaps inducing a few firms or a small fraction of individuals to take a given action, is a strong candidate for a reward-based policy. The application to U.S. food policy below discusses this further, and the analysis of popular support for incentive and disincentive policies makes repeated use of this result as an analytical tool.

We turn now to consider the effect of changes in the distribution of valuations for, *ex ante*, choosing $a = 1$ rather than $a = 0$. In particular, the change we consider is an "upward shift" in the distribution of valuations for compliance, F. This is a stronger assumption than is strictly necessary here, but for the sake of continuity with the needs of later sections, we restrict attention to these upward shifts.[13]

Definition 2 (Upward Shift in the Distribution of Valuations)**.** *$\hat{F}$ represents an upward shift of F if for $v \sim F$ and $\hat{v} \sim \hat{F}$, $\hat{v} = \mu + v$ for some $\mu \geq 0$.*

Proposition 1 (b)**.** *As the distribution of the population's valuations for choosing $a = 1$ rather than $a = 0$ shifts upwards: the level of compliance in the optimal policy intervention increases, and disincentives become less costly as the choice of policy with which to achieve the optimal level of compliance, while incentives become more costly.*

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 compliant with the socially-desirable behavior, $a = 1$. In a more *ex ante* compliant a population, fewer individuals must change their behavior in order to achieve a desired level of compliance, so this element of social cost is less of a hindrance to achieving higher levels of compliance. The policy intervention will be less distortionary.

Similar to the analysis of W, an upward shift in F has no direct effect on the attractiveness of using punishments instead of rewards. Through its effect on the optimal level of compliance, however, an upward shift in F indirectly reduces the cost of disincentive policies while increasing the cost of incentive policies. As before, this promotes higher levels of compliance in policy interventions, which in turn makes using punishments increasingly attractive relative to using rewards.

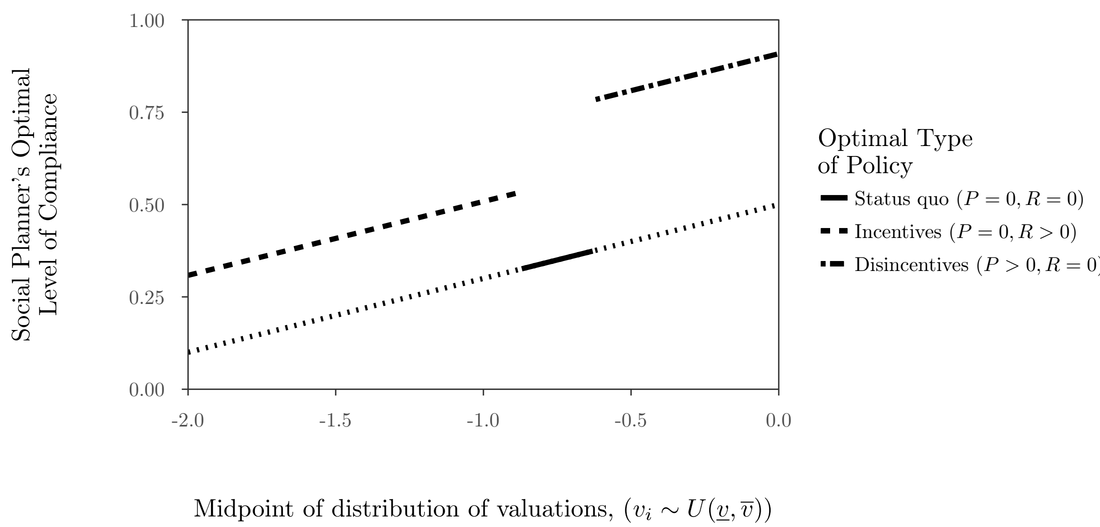
An upward shift in F affects the status quo utility more intricately than the change considered in part (a). The positive valuations of those *ex ante* complying (i.e., $v_i \geq 0$) increase, although there is also a corresponding decrease in the negative valuations required to achieve a given level of compliance, as just discussed. These effects work similarly on the social planner's evaluation of both the status quo and the optimal policy intervention. Additionally, however, $W(1 - F(0))$ increases, while $W(1 - F)$

[13] For Proposition 1(b), the results hold for any first-order stochastic increase in the distribution of valuations.

need not increase for $1 - F > 1 - \hat{F}$. We cannot conclude, then, that if under an upward shift will 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. Our example entails a uniform distribution of valuations, and the running variable is the midpoint of the distribution. The optimal level of compliance is increasing when a policy intervention is optimal, and this ultimately favors the use of punishments instead of the use of rewards. As discussed, it may be 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 optimal level of compliance and type of policy



Notes: The dotted line represents the status quo level of compliance, $1 - F(0)$. As per the functional forms from the example at the end of the previous section, $v_i \sim U(\underline{v}, \overline{v})$, and the horizontal axis represents $(\overline{v} + \underline{v})/2$. An increase in this quantity corresponds to an upward shift in the distribution of valuations ($F(\cdot)$ in the terminology of the model).

In the present analysis, F will play an important role below in modeling the presence of a subpopulation for which the policy intervention is not intended. The distribution of valuations would also be central to an analysis that incorporated behavioral phenomena. We turn next to analyze the role of the administrative costs of the different types of policy.

Proposition 1 (c). *A decrease in the marginal cost of using disincentives to induce more of the population to choose $a = 1$ rather than $a = 0$ with no change in fixed costs has competing effects on the level of compliance and type of policy in the optimal policy intervention. The same holds for increases* *in the marginal cost of using incentives to induce more compliance with* $a = 1$.

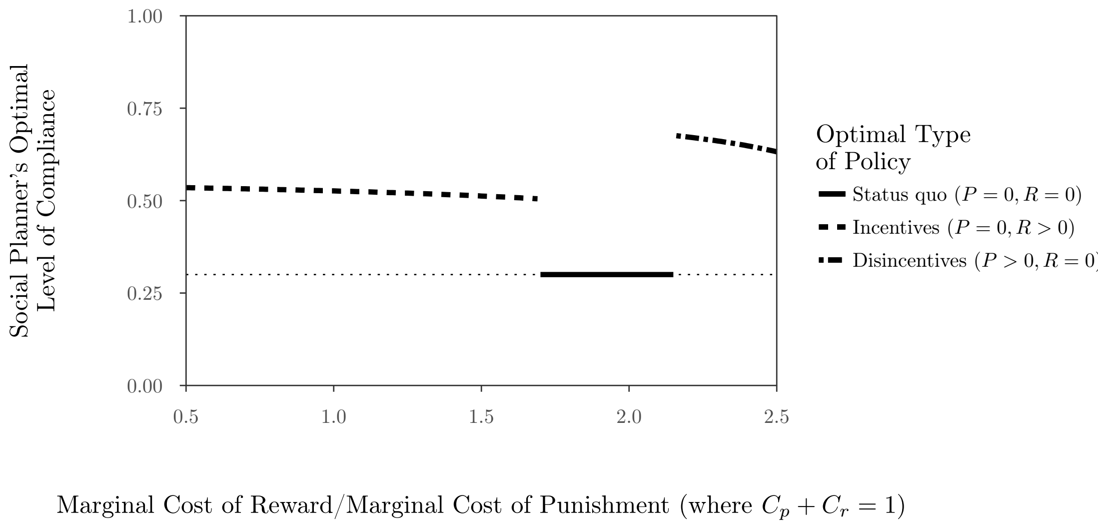
The final result in Proposition 1 is surprising precisely because of the ambiguity it highlights. Adjusting the marginal costs of the types of policies would seem to be the most straightforward way to favor one type over the other, but this is not the case. The changes have direct effects on both the optimal level of compliance and the optimal type of policy, but in such ways that the indirect effects find themselves at odds. We are unable to state without invoking additional assumptions that reducing the per-unit administrative costs of a type of policy makes it more likely that type policy will be optimal.[14]

The direct effect of lowering the marginal cost of either type of policy on the optimal level of compliance is to encourage larger policy interventions. The other direct effect of lowering the marginal cost of rewards is to make rewards cheaper relative to punishments and thus their use more attractive at any level of compliance. Meanwhile, because the fixed cost of a punishment policy has not changed, the other direct effect effect of lowering the marginal cost of punishments is to increase the cost of using disincentives at any level of compliance, increasing the relative attractiveness of using incentives. The indirect effect of making higher levels of compliance cheaper to achieve is to favor the use of punishments, and the indirect effect of making rewards relatively more attractive is to favor lower levels of compliance.

Figure 3 shows exactly these effects. The running variable is the ratio of the coefficients on the cost terms (see the example functional forms given above), which represent the marginal costs. To demonstrate changes in both variables, we restrict the coefficients to sum to one, although note that 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 we have tied a decrease in C_p 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.

[14]Specifically, the additional assumptions – likely related to the fixed cost – would also need to ensure that the average cost of a given policy decreased at all levels of compliance.

Figure 3: The effect of decreasing the marginal cost of disincentives and increasing the marginal cost of incentives on the optimal level of compliance and type of policy



Notes: The dotted line represents the status quo level of compliance, Γ_0. The ratio of marginal cost coefficients, C_r/C_p, is increasing along the horizontal axis. For purposes of illustration, $C_p + C_r = 1$, though of course this need not be the case more generally.

5 Modeling the Political Environment

In contrast to a social planner, an office-motivated politician seeks a policy that will garner the support of a majority of the population will support. Accordingly, we now undertake a characterization of the majority-preferred policy and its relationship to the social-planner's optimal policy. Part and parcel of this task will be engaging with the redistributive consequences of different types of policies. In this section, we establish a stylized depiction of redistribution with which we may engage the pressures of attaining popular support for policies. We also outline a similarly stylized model of elections that motivates our focus on the majority preference.

The Redistributive Implications of Incentives and Disincentives

We suppose redistribution, the disbursement of revenues from fines as well as the financing of subsidies, is achieved via lump-sum transfers applied uniformly across the population, as in Meltzer & Richard (1981). All members of the population receive an equal share of revenues collected from fines and carry an equal burden in the financing of subsidies. We continue to assume that the policy applies to the population at large, not just a distinguishable subpopulation

Fines are still only administered to those who choose $a = 0$, while subsidies are only given to those who choose $a = 1$. Given a fine of size P and a subsidy of size R, revenues from fines available for redistribution are given by $P \cdot F(-P-R) - C_p(1 - F(-P-R))$, while the required financing for a subsidy is given by $R \cdot [1 - F(-P-R)] + C_r(1 - F(-P-R))$. Every citizen receives/pays these quantities, which account for the deadweight administrative costs of the policies. Similarly, societal benefit from additional compliance with $a = 1$ in the population, given by $W(1 - F(-P-R))$, accrues to all individuals, regardless of whether they complied with the desired behavior.

It is helpful to clarify the utility a given member of the population, i, receives from a policy (P, R). The subscript "c" stands for complier (with $a = 1$) and "nc" for non-complier. Fact 1 from above determines when an individual will and will not comply, for which the utility function below accounts. Recall $1 - F(-P-R)$ is the proportion of the population that chooses the desired behavior, $a = 1$, given punishment of size P and reward of size R.

$$U^i(P,R) = \begin{cases} U^i_c(P,R) = \\ W(1-F(-P-R)) + F(-P-R)(P+R) - C_p(1-F(-P-R)) - C_r(1-F(-P-R)) + v^i \\ \text{ if } v^i \geq -P-R \\ U^i_{nc}(P,R) = \\ W(1-F(-P-R)) - [1-F(-P-R)](P+R) - C_p(1-F(-P-R)) - C_r(1-F(-P-R)) \\ \text{ if } v^i < -P-R \end{cases} \tag{4}$$

Remark 1. *Suppose* $(P^{**}_c, R^{**}_c) = \arg\max_{(P,R)} U^i_c(P,R)$*. Then* (P^{**}_c, R^{**}_c) *is the policy that maximizes utility for all ex post compliers.*

Suppose $(P^{**}_{nc}, R^{**}_{nc}) = \arg\max_{(P,R)} U^i_{nc}(P,R)$*. Then* $(P^{**}_{nc}, R^{**}_{nc})$ *is the policy that maximizes utility for all ex post non-compliers.*

Compliance is endogenous, but holding fixed an individual's action choice, the policy that maximizes her utility will maximize the utility of all those who made the same choice.

Remark 2. *No restriction that* $P, R \geq 0$ *appears here, as it did above.*

Negative values of P correspond to a policy rewarding those that choose $a = 0$. Negative values of R correspond to a policy punishing those that choose $a = 1$. We return below to discuss the possibility of $P, R < 0$ – policies that encourage socially harmful actions or discourage socially beneficial behavior.

Preferences over Incentive and Disincentive Policies

The next result establishes that the preference of the individual with the median valuation for compliance is equivalent to the majority preference. The support of the individual with the median valuation, which we refer to henceforth as the "median voter" (MV), is necessary and sufficient for majority support. This would be the winning policy in an election between two office-motivated candidates 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. We 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^{**}).

To prove the majority preference relation is equivalent to the preference relation of the individual with the median valuation, v^{MV}, we must show that preferences are monotonic in the valuations. We first note that the remark above implies that, for all i, $\arg\max_{(P,R)} U^i(P, R) \in \{(P_c^{**}, R_c^{**}), (P_{nc}^{**}, R_{nc}^{**})\}$. We then show that there exists a threshold valuation such that all members of the population with valuations above the threshold prefer (P_c^{**}, R_c^{**}), while those with valuations below the threshold prefer $(P_{nc}^{**}, R_{nc}^{**})$. This demonstrates the necessary monotonicity of preferences in the valuations, and we may then invoke the median voter theorem (Gans & Smart 1996).

This result establishes that if $(P^{**}, R^{**}) = (P_c^{**}, R_c^{**})$, then the median voter along with a majority of the population will choose $a = 1$. Conversely, if $(P^{**}, R^{**}) = (P_{nc}^{**}, R_{nc}^{**})$, then the median voter along with a majority of the population will choose $a = 0$. If the median voter complies (choosing $a = 1$) *ex post*, then so will a majority; if she does not comply with the desired behavior *ex post* (choosing $a = 0$), then neither will a majority.

6 The Majority-Preferred Policy

We now turn to characterizing the winning policy from Lemma 3, (P^{**}, R^{**}). As per the conclusions above, this entails characterizing (P_c^{**}, R_c^{**}) and $(P_{nc}^{**}, R_{nc}^{**})$ and the conditions under which (P^{**}, R^{**}) shifts from one to the other. The remark below clarifies that the winning policy will, as with the social planner's optimal policy, entail the use of only one type of policy.

Remark 3. *All individuals prefer the use of either an incentive or a disincentive policy – but not both – to achieve any given level of compliance.*

This insight follows from precisely the same logic as it did for the social planner in the previous section. Further, it allows us to adopt an approach to analyze the majority-preferred policy that closely mirrors the approach we took to analyze the optimal policy from the social planner's perspective. Indeed, Proposition 3 in Appendix Section B.2 states that the comparative statics of the majority-preferred policy are highly similar to the comparative statics of the social planner's optimal policy (see Proposition 1). This is especially true when limiting consideration to the majority-preferred policy intervention, formally defined below, and the social planner's optimal policy intervention, as defined above. As with the social planner's optimal policy, characterizing the overall majority-preferred policy (vis-à-vis the majority-preferred policy intervention) requires some care. 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 attractive relative to the other.

Definition 3 (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 $R^{**} \neq 0$.*

For members of the population and social planner alike, increased compliance makes punishments increasingly attractive relative to rewards, and the use of punishments favors increasing compliance while the use of rewards favors decreasing compliance. As a result, and as Propositions 1 and 3 make explicit, the social planner's optimal policy intervention and the majority-preferred policy intervention respond similarly to increases in the marginal societal benefit from additional compliance, upward shifts in the distribution of valuations, and decreases (resp. increases) in the marginal cost of disincentives (resp. incentives).

The majority-preferred policy and the social planner's optimal policy are not the same. The more interesting characterization of the majority-preferred policy is in relation to the social planner's optimal policy, and this is the focus of the next proposition. It states that the median voter's preferred policy intervention "sandwiches" the social planner's optimal policy intervention, and the two 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 level of compliance.

A majority will either reward itself for choosing $a = 1$ or punish a minority who choose $a = 0$ excessively, achieving a higher level of compliance than the social planner's optimal.

Increases in the marginal benefit of compliance with $a = 1$ or an upward shift in the distribution of valuations favor the outcomes in which a majority choosing $a = 1$ imposes a larger-than-efficient disincentive on the minority choosing $a = 0$, or in which a majority choosing $a = 0$ institutes a smaller-than-efficient incentive for the minority choosing $a = 1$.

The implications regarding majority compliance follow immediately from the fact that the median voter complies if and only if a majority of individuals are complying. As the choice to take $a = 1$ of the member of the population with the median valuation is a monotonically increasing step function of the level of *ex post* compliance, parameter changes that increase the level of compliance naturally make it more likely that the median will join the set of compliers.[15]

In effect, an *ex post* complier's marginal utility function is the same as the social planner's, but with a *greater* marginal net benefit at all levels of compliance. An *ex post* non-complier's marginal utility function is the same as the policymaker's, but with a *lower* marginal net benefit at all levels of compliance. Proposition 1 tells us that maximizing an *ex post* complier's utility will lead to greater levels of compliance than the social planner's optimal level and, indirectly, favor the use of punishments over rewards. Maximizing an *ex post* non-complier's utility 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. An implication of this is that, relative to *ex post* non-compliers, *ex post* compliers will desire higher levels of compliance and look more favorably upon the use of punishment-based policies.

Proposition 2 codifies what likely would have been our intuition, namely, that a majority excessively rewards itself for complying or punishes a minority for not complying, and that a majority insufficiently rewards a minority of compliers or punishes itself for not complying. That a majority would ever choose to punish its own non-compliance or reward its own compliance might seem surprising, and again our intuition serves us well. These two outcomes are less likely in a sense. Exogenous changes that would lead a majority to comply (resp. not comply) increase the relative attractiveness of punishments (resp. rewards).

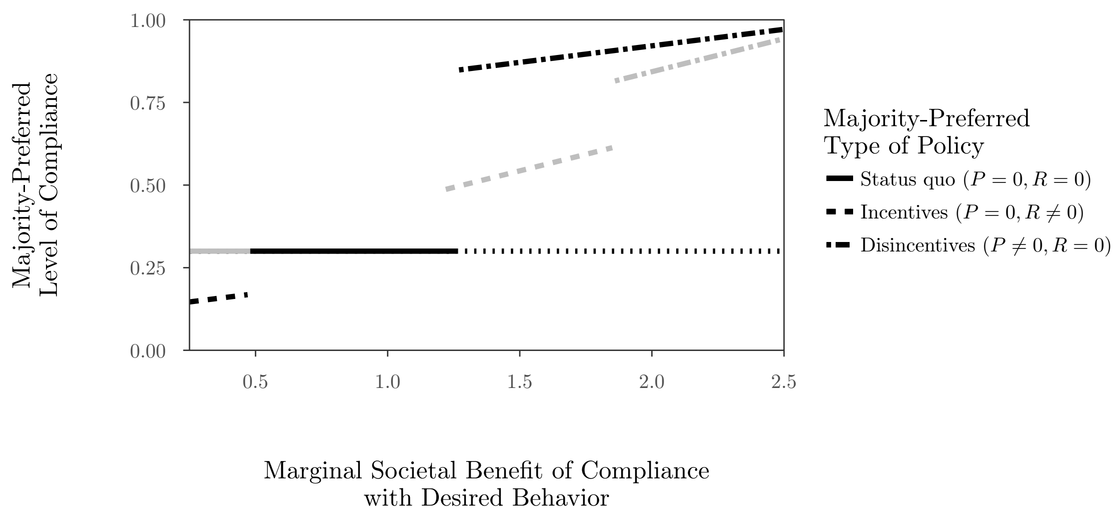
Figures 4-6 illustrate these results.[16] The black lines correspond to the majority-preferred level

[15]More accurately, 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.

[16]Figures 5-6 appear in the appendix.

of compliance and type of policy. The gray lines correspond to the social planner's optimal level of compliance and type of policy (where line type indicates the type of policy according to the legend). The gray lines always lie inside of the black lines, demonstrating that the median voter's preferred policy will not achieve the social planner's preferred level of compliance, unless both prefer the absence of a policy intervention, the status quo. Further, for majority-preferred levels of compliance in which the member with the median valuation chooses $a = 1$ *ex post*, i.e., $1 - F \geq 1/2$, indirect effects seem to strongly favor the use of punishments rather than rewards.

Figure 4: The effect of increasing the marginal benefit to society of compliance on the median voter's most-preferred level of compliance and type of policy



Notes: The dotted line represents the status quo level of compliance, $1 - F(0)$. The gray lines correspond to the social planner's optimal level of compliance and type of policy. The horizontal axis represents increases in the marginal benefit to society of compliance, W', or g in the context of the example functional forms that underlie the figures.

A particularly surprising 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. Negative punishments or rewards would never have been optimal from the social planner's perspective, as they would result in less social benefit and additional lost valuations. In the context of popular support, however, encouraging the socially desirable action garners support among the population only in as much as the social benefit contributes to their individual utility enough to outweigh redistributive concerns.

Encouraging the Socially Harmful Action

When seeking to maximize the utility of the median voter, and as was the case when seeking to maximize the social planner's utility, the status quo level of compliance, $1 - F(0)$ is privileged only because it is the sole level of compliance that may be achieved without any administrative costs. When the median voter prefers another level of compliance (even after taking into account the administrative costs incurred in achieving it), it need not be the case that this policy will entail encouraging $a = 1$, as it was in the case of the social planner. The median voter need not take into account any individuals' valuations other than her own, save for the role the valuations play in determining compliance.

Policies do exist which willingly encourage a harmful action or deter a beneficial action, and this outcome ought to be possible in any positive model of the politics of policymaking. A satisfying account would not require that some of the population believes $a = 0$ to be beneficial to society at large, but rather would suppose agreement on which is the desirable action and allow self interest alone to generate harmful policies. Since punishments turn into rewards and rewards into punishments, it is helpful to consider the following possibilities that may obtain in which the share of the population choosing $a = 1$ *ex post* is smaller than in the status quo:

1. Majority of population chooses $a = 0$, minority of population taxed for choosing $a = 1$ ("rewarded with negative subsidy")

2. Majority of population chooses $a = 0$, minority of population subsidized in choosing $a = 0$ ("punished with negative fine")

3. Minority of population chooses $a = 1$, majority of population taxed for choosing $a = 1$ ("rewarded with negative subsidy")

4. Minority of population chooses $a = 1$, majority of population subsidized in choosing $a = 0$ ("punished with negative fine")

The next section provides examples of such policies, as well as more standard public policies. The question we wish to answer here is when it is likely to be the case that $1 - F(-P^{**} - R^{**}) \leq 1 - F(0)$, and how this relates to majority compliance. Using the same comparative statics techniques we have employed throughout, we may reverse the logic of claims made to this point to generate insights into the conditions under which we would observe a policy actively induce less compliance with the desired behavior than under the status quo.

Corollary 1. *As the added value to society from additional compliance with $a = 1$ rather than $a = 0$ decreases at all levels of compliance or the distribution of the population's valuations for choosing $a = 1$ rather than $a = 0$ shifts downwards, the level of compliance in the majority-preferred policy decreases.*

This leads to an increase in the administrative cost of a policy that applies to those choosing $a = 0$ to achieve the majority-preferred level of compliance but a decrease in the cost of a policy that applies to those choosing $a = 1$, and the median voter's utility from choosing $a = 0$ increases, while her utility from choosing $a = 1$ decreases.

When characterizing the majority-preferred policy relative to the social planner's optimal policy, we found that the conditions favoring the use of reward policies (i.e., policies that apply to those choosing $a = 1$) favored smaller levels of compliance with $a = 1$ than the social planner would have preferred because such policies favor the median voter choosing $a = 0$. At the extreme, these "rewards" are so small as to become fines for those choosing $a = 1$. Among policies with the effect of encouraging the socially harmful/less beneficial $a = 0$, our analysis suggests that disincentives for $a = 1$ with a majority of the population choosing $a = 0$ are, in a sense, more likely than incentives for $a = 0$. An illustration of this appears in Figure 4.

7 Accounting for Unaffected Subpopulations

To this point, we have ignored the modeling of a subpopulation not confronted with a choice between $a = 1$ and $a = 0$. We now engage this issue, considering two cases: 1) we are unable to identify subpopulations of interest, 2) we are able to differentiate between subpopulations, as we have assumed thus far. We take each in turn.

Many policies must apply to nearly the whole population. Even if a large segment of the population is already tacitly complying with a desired behavior or, conversely, effectively unable to comply with a desired behavior, often policy must nonetheless apply to this "unaffected" subpopulation, as well as the subpopulation of interest. In this case, the results regarding the first-order stochastic dominance of valuation distributions apply and provide an intuitive reconciliation.

The presence of an unaffected subpopulation that is effectively in compliance with desired policy (e.g., non-drivers not speeding) represents a more "compliant" distribution of valuations for the whole population than the distribution of valuations for the subpopulation of interest (drivers). From Proposition 1(b), we know that this favors the use of disincentives. In the example of discouraging speeding, this formalizes our intuition regarding the inefficiency of rewarding a substantial segment of the population (non-drivers) for not speeding when they were of no risk for doing so anyway. From the social planner's perspective, these conditions favor the use of fines and a large level of compliance when it comes to regulating the use of our roads.

Or consider the example of copyright for artistic works, or patents for inventions. While government wishes to encourage innovation, it is unable to target the subpopulation of possible innovators, artistic or otherwise. This constitutes the presence of a large subpopulation that will never "comply" with the behavior government wishes to encourage. The distribution of valuations of the population as a whole is less compliant than the distribution of valuations for compliance within the subpopulation of interest. Referencing Proposition 1(b) again, these conditions favor a social planner using rewards to spur innovation by a small share of the overall population.

In many circumstances, however, it is easy to differentiate those in a subpopulation of interest from those who are not. For instance, it is often the case that the subpopulation we wish to affect with policy is an industry. It is usually straightforward to identify firms from individuals and, further, firms in a certain industry from firms in other industries. We call the portion of the population that would not receive either a reward or a punishment under a given policy the "unaffected subpopulation" – e.g., those who do not own cars would not be penalized for failure to possess vehicle registration, those without cropland would be ineligible for farm subsides.

If enforcement is able to discriminate between the subpopulation of interest and the rest of the population, then the analyses of the social planner's optimal policy hold without further modification. We take the distribution of valuations in the subpopulation as the distribution of valuations for the population as a whole. 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 may affect the analysis. This population certainly benefits from any additional compliance with the desired behavior from the population of interest. Furthermore, such individuals 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 $\lambda \leq 1$. Denote an arbitrary individual in this group by ℓ. The entire population is still of mass 1, so the size of the subpopulation of interest is $1-\lambda$. The "subpopulation of interest" refers to the portion of the population to whom any incentive or disincentive would apply.

As a point of entry, consider the implications of incentive and disincentive policies for an individual, ℓ. Under a policy that involves the use of rewards (as well as potentially punishments), ℓ would have to contribute $(1-\lambda)R(1-F(-P-R))+C_r((1-\lambda)(1-F(-P-R)))$ to finance the subsidy, but receive no compensation for her behavior. While she did "not not comply," she also did not comply – she is simply not a member of the subpopulation of interest. Under a punishment-based policy, ℓ will not receive any fine, but she will receive $(1-\lambda)PF(-P-R)-C_p((1-\lambda)(1-F(-P-R)))$.

With regards to policies applied to those choosing $a=1$, ℓ shares the same utility function as an *ex post* non-complier. With regards to policies applied to those choosing $a=0$, however, ℓ shares the same utility function as an *ex post* complier. Unlike a member of the subpopulation of interest, the relevant utility function does not hinge on the anticipated compliance of ℓ. Rather, appealing to ℓ will consist of comparing the most-preferred punishment-based policy for an *ex post* complier to the most-preferred reward-based policy for an *ex post* non-complier, and then comparing the best of those to the utility ℓ receives in the absence of any further policy intervention, namely $W((1-\lambda)(1-F(0)))$.

Our final result characterizes the preferences of a member of an unaffected subpopulation. We again suppose that the enforcement technologies do not depend on $P, R \gtreqless 0$, but rather depend smoothly on $1-F$. We also set aside the possibility that the status quo might be the majority-preferred policy and instead focus on the majority-preferred policy intervention.

Corollary 2. *Assume that the share of the population that is unaffected by the policy is given by $\lambda \geq \frac{1}{2}$, such that a majority of the population will receive neither incentive nor disincentive under a policy intervention. Denote a member of the unaffected subpopulation by ℓ.*

Let $P^{**} \neq 0$ denote the best disincentive policy intervention from the perspective of a member of the affected subpopulation with $v^i > -P^{**}$ (such that i chooses $a=1$). Let $R^{**} \neq 0$ denote the best policy intervention from the perspective of a member of the affected subpopulation with $v^i < -R^{**}$ (such that i chooses $a=0$).

An increase in the marginal benefit to society 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^{**}.

The same holds for an upwards shift in the distribution of valuations among the affected subpopulation for choosing $a=1$ rather than $a=0$.

A member of the population ineligible for any incentives or disincentives identifies with *ex post* compliers or non-compliers based on the particular policy used, rather than her valuation for compliance. The results above are merely reformulations of the results we have derived to this point. Indeed, the findings regarding policies encouraging $a = 0$ as well as the comparisons to the socially optimal policies apply in this context, as well.

When a subpopulation not directly affected by incentives or disincentives in a given policy domain is sufficiently large so as to effectively decide policy, it will always be the case that rewards will achieve smaller than the socially optimal level of compliance and punishments will achieve larger than the socially optimal level of compliance. As above, the downward pressure on rewards may drive them to become negative, constituting a disincentive for choosing $a = 1$. 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 Applications of the Model to Food Policy

We return now to discuss the food policy examples outlined in the introduction. The discussion will be brief but will aim nonetheless to provide a sense for how the results above might be used heuristically to think about the use of incentives and disincentives in public policy. A deeper analysis of any given policy domain would no doubt make more careful use of the ideas presented here and likely involve a wealth of other considerations.

Why might the Conservation Reserve Program utilize incentives? It is likely that the benefit to rotating cropland out of usage is quickly overtaken by the benefit of having cropland in use after a relatively small level of compliance. We certainly do not wish for all farmland to sit idle. This is precisely the sort of behavior for which an incentive is more appropriate than a disincentive. Compliance will and should be low, so rewards are the cheaper approach to achieving the desired ends.

The "sugary drink taxes" are another matter entirely. Recent research has found that even modest taxes do seem to result in decreases in consumption, so efficacy is not entirely in question,[17] although often the taxes – just a few cents per bottle – are seen more as a regressive tax than a deterrent.[18] Despite increasing adoption, however, these taxes remain incredibly unpopular. Such taxes may be an example of the case in which the winning policy punishes the majority of the population that nonetheless takes the less desirable action. As expected in such a circumstance, the punishment will

[17] `http://www.wsj.com/articles/soda-consumption-falls-after-special-tax-in-california-city-1471982400`

[18] To which it is often replied that the associated health risks are also regressive in their incidence.

achieve a lower level of compliance than would maximize social welfare.

Again with regards to individual consumption patterns, a number of incentive-based initiatives have been piloted of late. Among them are the Healthy Incentives Pilot in which recipients of Supplemental Nutrition Assistance Program (SNAP) money effectively receive cash back for purchases of fruits and vegetables. Other programs have used rewards to encourage children to make healthier eating choices in the context of school lunches (Just & Price 2013, List & Samek 2017). If compliance with these initiatives is desirable even as more and more take it up, and if the goal for these programs is to be rolled out on ever larger scales, then one implication of the model is that incentives may become more costly than disincentives at high levels of compliance. Should SNAP money spent on unhealthy foods be taxed? Should unhealthy lunch options be harder or more expensive to obtain? These are questions with which these programs will need to engage as they scale up. Incentives work in pilots, but high levels of compliance and the use of punishments are complementary.

Finally, an example of a socially beneficial policy being implicitly discouraged may be found in organic food certification (Wilde 2013, ch. 3). Certifying a farm as organic requires a costly certification process. While financial assistance may be procured through EQIP, farmers are often left to finance the process themselves. While most would agree that reduced use of pesticides and sub-therapeutic use of antibiotics imparts at least some benefit, farms are essentially being taxed for their compliance with this desirable behavior. That valuations for taking this action are such that compliance is likely to be low even in the presence of incentives, it may not be surprising that the outcome of the political process was the tax the small share of the population taking the desirable action, i.e., the use of a negative reward on compliers.

9 Conclusion

We have found that the higher the benefit of additional compliance with a desired behavior and the larger status quo compliance would be, the more we ought to observe the use of incentives rather than disincentives. By incorporating stylized accounts of redistribution and elections, we found that the those same conditions make it likely that a majority of compliers will punish non-compliers excessively or that a majority of non-compliers will reward compliers insufficiently (relative to the socially optimal level). The latter tendency may be so strong as to permit taxes on individuals taking the desired behavior, as in the case of organic farm certification. The mechanism driving the results throughout was the complementarity between using punishments rather than rewards and achieving higher levels of compliance. Introducing redistribution made this relationship even stronger.

As the model stands now, even if risk were introduced into the enforcement of incentives and disincentives and risk preferences introduced into the compliance decision taken by members of the population, it would have limited if any effect on the conclusions. Similarly, if costs were allowed to increase in the size of the policy (as well as in the measure of individuals to whom the policy is applied), the statement of results would change (as a result of employing the single-crossing property rather than the stronger increasing differences condition), but the findings would remain essentially unaltered. It is true that introducing both of these adjustments to the model together would result in upward pressure on costs by way of probabilistic enforcement of larger policy interventions.

While the findings presented herein are fairly robust to the addition of minor behavioral modifications or cost-function complexities, these two avenues seem to hold promise for additional inquiry on the use of incentives and disincentives. Specifically, incorporating population-based behavioral effects, such as crowding in/out, notions of norms and mores, or coordination in interactions among the population would offer a bridge between the rather institutionally focused account in this paper and the large extant behavioral literature that studies 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.

Although our formal results could not offer firm predictions on the effect of changes in the rate at which costs accrue as a function of compliance, this seems to be an invitation for further research on this aspect. Based in specific applications, adding structure to the cost functions and they ways in which the administrative technology may change could allow more definitive insights to arise. This would likely entail changes in fixed costs along with changes marginal costs.

Finally, future work would do well to focus on inequality in this context. Characterizing the implications of incentives and disincentives for inequality would be a first step. A better understanding of policy choice based on the correlation of wealth and valuation for compliance, though, holds potential for an array of new insights about the use of incentives and disincentives in public policy.

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Appendix

A Proofs from Section 3-4: Social Planner

A.1 Reframing the social planner's problem

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

Proof of Lemma 1. Recall that $C_p(\cdot)$ is decreasing and $C_r(\cdot)$ is increasing in the argument, $1 - F$. Additionally, the cost of using punishments is zero at full compliance ($1-F = 1$), and the cost of using rewards is zero at full non-compliance ($1 - F = 0$). As such, there must exist a level of compliance, denote it $1 - \tilde{F}$, such that $C_p(1 - \tilde{F}) = C_r(1 - \tilde{F})$.

For all lower levels of compliance, $1 - F < 1 - \tilde{F}$, $C_r(1 - F) < C_p(1 - F)$, so rewards are the cheaper type of policy with which to attain a given level of compliance. Conversely, for higher levels of compliance, $1 - F > 1 - \tilde{F}$, $C_p(1 - F) > C_r(1 - F)$, 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 achieve any level of compliance, then, only one type of policy should be employed. ■

Remark 4. *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 approach are still valid even 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 level of compliance 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 achieve that level of compliance. Yet this level of compliance will never be the level of compliance at which the marginal administrative costs are equal, and so it will still 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.*

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 the discussion in text would suggest. We denote the level of *ex post* compliance achieved 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 forgo a policy intervention is given by (Γ_0, ϕ).

Lemma 4 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, then (Γ^*, θ^*) is the optimal policy under the reframing, where $\theta^* = p$ and $\Gamma^* = 1 - F(-P^*)$. The analogous statement holds for R. Lemma 1 plays a crucial role in the proof.

Lemma 4. $(\Gamma^*, \theta^*) := \max_{\Gamma \geq \Gamma_0, \theta \in \{\phi, r, p\}} W(\Gamma) - \int_0^{\Gamma} X(\tilde{\Gamma}) d\tilde{\Gamma} - C_\theta(\Gamma)$ *iff* $(\mathbb{I}_{\theta^* = p} \cdot X(\Gamma^*), \mathbb{I}_{\theta^* = r} \cdot X(\Gamma^*)) = (P^*, R^*) := \max_{P \geq 0, R \geq 0} W(1 - F(-P - R)) + \int_{-P-R}^{\overline{v}} v f(v) dv - \mathbb{I}_{P > 0} C_p(\Gamma) - \mathbb{I}_{R > 0} C_r(\Gamma)$.

Proof of Lemma 4. 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^*). The one-to-one and onto transformation between the two pairs is sufficient. If $(\mathbb{I}_{\theta^* = p} \cdot X(\Gamma^*), \mathbb{I}_{\theta^* = r} \cdot X(\Gamma^*)) \neq (P^*, R^*)$, then it would suggest some other $(\tilde{P}, \tilde{R})$ were 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:

$$U^{SP}(\Gamma, \theta) = \begin{cases} U_p^{SP}(\Gamma) = W(\Gamma) - \int_0^{\Gamma} X(\tilde{\Gamma}) d\tilde{\Gamma} - C_p(\Gamma) & \text{if } \theta = p, \Gamma > \Gamma_0 \\ U_r^{SP}(\Gamma) = W(\Gamma) - \int_0^{\Gamma} X(\tilde{\Gamma}) d\tilde{\Gamma} - C_r(\Gamma) & \text{if } \theta = r, \Gamma > \Gamma_0 \\ U_\phi^{SP}(\Gamma) = W(\Gamma) - \int_0^{\Gamma} X(\tilde{\Gamma}) d\tilde{\Gamma} & \text{if } \theta = \phi, \Gamma = \Gamma_0 \end{cases} . \tag{5}$$

The restriction to $(P, R) \geq 0$ becomes $\Gamma \geq \Gamma_0 := 1 - F(0)$, which we impose on the social planner's transformed maximization problem.

Ashworth & Bueno de Mesquita (2006) provide conditions of complementarity, formally supermodularity, under which such results are possible without further parameterization. Specifically, we seek to show each pair of arguments of the utility function has increasing differences. This amounts to demonstrating that the incremental return of each pair of arguments is increasing.

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 (Γ_0, ϕ) as a second step, after first choosing between p and r. In the context of Equation 5, 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., $p > r$),

$$U^{SP}(\hat{\Gamma}, \hat{\theta}) - U^{SP}(\Gamma, \hat{\theta}) \geq U^{SP}(\hat{\Gamma}, \theta) - U^{SP}(\Gamma, \theta). \tag{6}$$

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

$$-C_p(\hat{\Gamma}) - C_p(\Gamma) \geq -C_r(\hat{\Gamma}) + C_r(\Gamma), \tag{7}$$ [19]

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 to 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 each incentive and disincentive policies.

If it can then be shown that U^{SP} has increasing differences with respect to an exogenous parameter and each choice variable, then we may conclude that an increase in that parameter leads to an increase in the optimal choice of (Γ, θ), $\Gamma > 0, \theta \neq \phi$. We need not worry about 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 (Γ_0, ϕ) in response to parameter changes.

[19] This constitutes a proof of Lemma 2.

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

Proposition 1' (a). *Let the optimal level of compliance, $\Gamma \in [\Gamma_0, 1]$, and type of policy, $\theta \in \{p, r\}$, 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 $\Gamma^* > \Gamma_0$, 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 $\Gamma^*, \hat{\Gamma}^* > \Gamma_0$, 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^{PM} from an increase in Γ but decreases the incremental return of U^{PM} 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^{PM} is supermodular in (Γ, θ). Additionally, $\{[\Gamma_0, 1] \times \{p, r\}\}$ 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^{PM} 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^{PM} does have increasing differences in $(\Gamma, \theta; W(\cdot), F(\cdot))$. As such, $(\Gamma^*, \theta^*) = \underset{(\Gamma,\theta) \in \{[\Gamma_0,1] \times \{p,r\}\}}{\arg\max} U^{PM}(\Gamma, \theta; W(\cdot), F(\cdot))$ is monotone nondecreasing in $(W(\cdot), F(\cdot), \Gamma_0)$.[20] For Proposition 1(c), we wish to demonstrate that $U^{PM}(\Gamma, \theta; C_p, C_r)$ has 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).

[20] We address the matter of Γ_0 after item 2 below.

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 $\frac{\partial}{\partial \Gamma}(U^{PM}(\Gamma, \theta; \hat{W}) - U^{PM}(\Gamma, \theta; W))$. If that quantity is weakly positive, increasing differences may be inferred. Note that

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

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:

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

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

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

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

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

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

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

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 $[\Gamma_0, 1] = (1 - F(0), 1)$, which is strictly smaller than $[1 - \hat{F}(0), 1]$ in the strong set ordering.

To show that the strict single crossing property is satisfied, the incremental return must be strictly larger than zero for parameter values strictly larger than the value at which the incremental return equals zero. The strict increasing differences in $(\Gamma; F)$ suffice. For $(\theta; F)$, we cannot establish the strict single-crossing property. Whether the combination of strictly increasing differences in (Γ, θ) and $(\Gamma; F)$ suffices is for the moment an open question. I think so, as $(\hat{\Gamma}, \theta) > (\Gamma, \theta)$, and the theorem just states $x > \hat{x}$. [May just relax the lower bound on the constraint...]

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

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

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

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

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

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

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

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

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

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

This concludes the proof. ■

B Proofs from Sections 5-6: Majority Preference

B.1 Reframing the politician's problem

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. $U^i(P_c^*, R_c^*) - U^i(P_{nc}^*, R_{nc}^*)$ is strictly increasing in v_i. Set $v^{\tilde{i}}$ s.t. $U^{\tilde{i}}(P_c^*, R_c^*) = U^{\tilde{i}}(P_{nc}^*, R_{nc}^*)$. It must be that $\forall i$ s.t. $v^i > v^{\tilde{i}}$, $U^{\tilde{i}}(P_c^*, R_c^*) > U^{\tilde{i}}(P_{nc}^*, R_{nc}^*)$.

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. ■

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*. 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 choose $a = 1$ when $v^{MV} \geq -X \Leftrightarrow \Gamma > \frac{1}{2}$.

$$U^{MV}(\Gamma, \theta) = \begin{cases} U^{MV}_{c,\theta}(\Gamma) = W(\Gamma) - (1-\Gamma)F^{-1}(1-\Gamma) - C_\theta(\Gamma) + v^{MV} & \text{if } \Gamma \geq \frac{1}{2} \\ U^{MV}_{nc,\theta}(\Gamma) = W(\Gamma) + \Gamma F^{-1}(1-\Gamma) - C_\theta(\Gamma) & \text{if } \Gamma < \frac{1}{2} \end{cases} \tag{8}$$

As above, we wish to demonstrate that U^{MV} has increasing differences in (Γ, θ). 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 and the use of punishments more favorable. From there, we may derive results about the compliance of the decisive voter and the circumstances in which $a = 0$ 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 in $(\Gamma, \theta), \theta \in \{p, r\}$[21] proceeds exactly as did the inequality in 6, although showing increasing differences in the choice variables and the parameters of interest presents a small hurdle. As above, we seek increasing differences with respect to pointwise increases in the marginal benefit, W, and first-order stochastic increases of the distribution of valuations for compliance, F. The latter, however, is no longer straightforward without additional structure. As such, we limit consideration to "shifts" in a distribution, a particular type of first-order stochastic increases. Specifically, we say $\hat{F}$ represents a shift of F if for $v \sim F, \hat{v} \sim \hat{F}$, $\hat{v} = \mu + v, \mu \geq 0$. Ultimately, the results of Proposition 1 apply to the Condorcet winning policy as they did to the social-welfare maximizing policy, with an additional implication regarding the majority's *ex post* decision to comply.

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

Proposition 3. *Let the Condorcet winning policy, consisting of a level of compliance, $\Gamma \in [0,1]$, and type of policy, $\theta \in \{p, r\}$, 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 Condorcet 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 $\Gamma^{**} > \Gamma_0$, then $\hat{\theta}^{**} \geq \theta^{**}$.

(b) Let $(\hat{\Gamma}^{**}, \hat{\theta}^{**})$ be the Condorcet winning policy under $\hat{F}$ and $\hat{\alpha}^{**}$ be the action choice of a majority of the population.

If $\hat{F} \leq F$, such that the distribution of valuations under $\hat{F}$ is a shift of the distribution under F, then if $\theta^{**}, \hat{\theta}^{**} \neq \phi$, then $\hat{\Gamma}^{**} \geq \Gamma^{**}$, $\hat{\theta}^{**} \geq \theta^{**}$, and $\hat{\alpha}^{**} \geq \alpha^{**}$.

(c) Let $(\hat{\Gamma}^{**}, \hat{\theta}^{**})$ be the Condorcet winning policy under $\hat{C}_p$ and/or $\hat{C}_r$, where $\hat{C}_p' \leq C_p'$ and $\hat{C}_r' \leq C_r'$.

The relationships of $\hat{\Gamma}^{**}$ to Γ^{**}, $\hat{\theta}^{**}$ to θ^{**}, and $\hat{\alpha}^{**}$ to α^{**} are ambiguous.

Proof of Proposition 3. We need only show increasing differences or the single-crossing property 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. $\hat{W} \succ W \Rightarrow \hat{W}' > W', \forall \Gamma \in [0,1]$

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

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

2. $\hat{F}(\hat{v}) \succ F(v) \Rightarrow \hat{v} = \mu + v$, $\mu \geq 0$.

$(\Gamma, F):\ \frac{\partial^2}{\partial \Gamma \partial \mu} = \frac{\partial}{\partial \mu} F^{-1}(\Gamma, \mu) > 0, \forall \Gamma \in [0,1]$

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

3. We cannot definitively sign the change in the Condorcet winning policy given the partial ordering on the costs for the same reason as in Proposition 1.

Finally, α is an increasing function of Γ^{**}, and the effects of compliance/non-compliance were accounted for in the analysis of U^{MV}. ■

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 Condorcet winning policy if limited to* $\Gamma \in [\Gamma_0, 1] \Leftrightarrow P, R > 0$*. 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* $\Gamma^{**} > \Gamma^*$*.*

Increases in the marginal benefit of compliance or an upward shift in the distribution of valuations 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.

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

$$\begin{aligned} \frac{\partial U^{MV}_{c,\theta}}{\partial \Gamma} &= W' + \frac{1-\Gamma}{f(F^{-1}(1-\Gamma))} + F^{-1}(1-\Gamma) - C'_\theta \\ &\geq \\ \frac{\partial U^{PM}_{\theta}}{\partial \Gamma} &= W' + F^{-1}(1-\Gamma) - C'_\theta \qquad\qquad , \forall \Gamma \in [\Gamma_0, 1]. \\ &\geq \\ \frac{\partial U^{MV}_{nc,\theta}}{\partial \Gamma} &= W' - \frac{\Gamma}{f(F^{-1}(1-\Gamma))} + F^{-1}(1-\Gamma) - C'_\theta \end{aligned}$$

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).

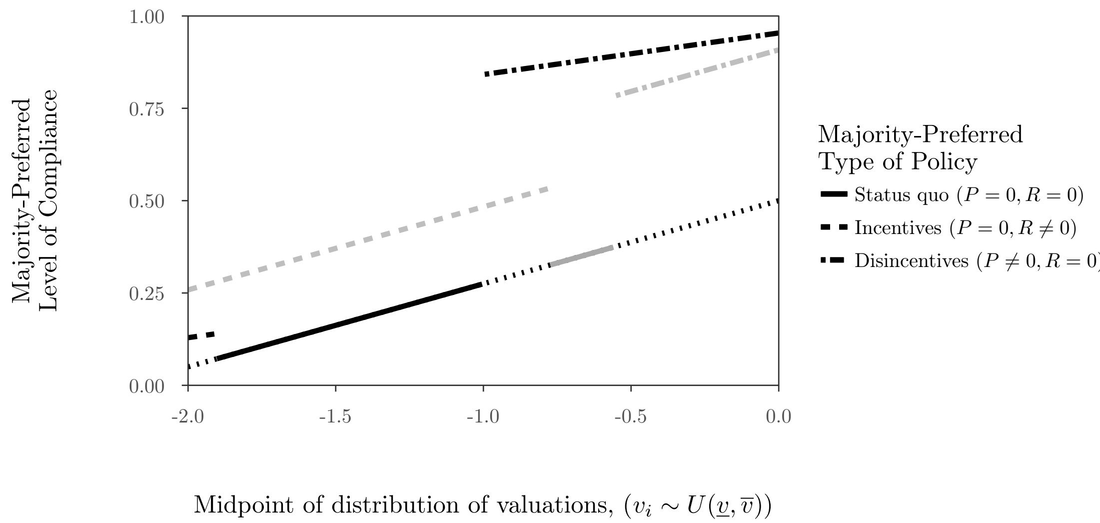
Applying Proposition 1 to $U^{MV}_{nc,\theta}$ and $U^{MV}_{c,\theta}$, the results regarding $\Gamma^{**} \gtrless \Gamma^*$ follow immediately. The indirect effect of increasing Γ is that $\theta^{**} \geq \theta^*$.

The comparative statics stem from an application of Proposition **??**. ■

As noted in text, further illustration of the preceding result may be found in these figures:

Corollary 1'. *Let the Condorcet 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* $(\Gamma^{**}, \theta^{**})$*.*

Figure 5: The effect of shifting upwards the distribution of valuations for compliance with $a = 1$ rather than $a = 0$ on the median voter's most-preferred level of compliance and type of policy



Notes: The dotted line represents the status quo level of compliance, $1 - F(0)$. The gray lines correspond to the social planner's optimal level of compliance and type of policy. The horizontal axis measures $(\overline{v} + \underline{v})/2$, which corresponds to the decisive voter's valuation for compliance. An increase in this quantity also signifies an upward shift in the distribution of valuations, $F(\cdot)$.

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

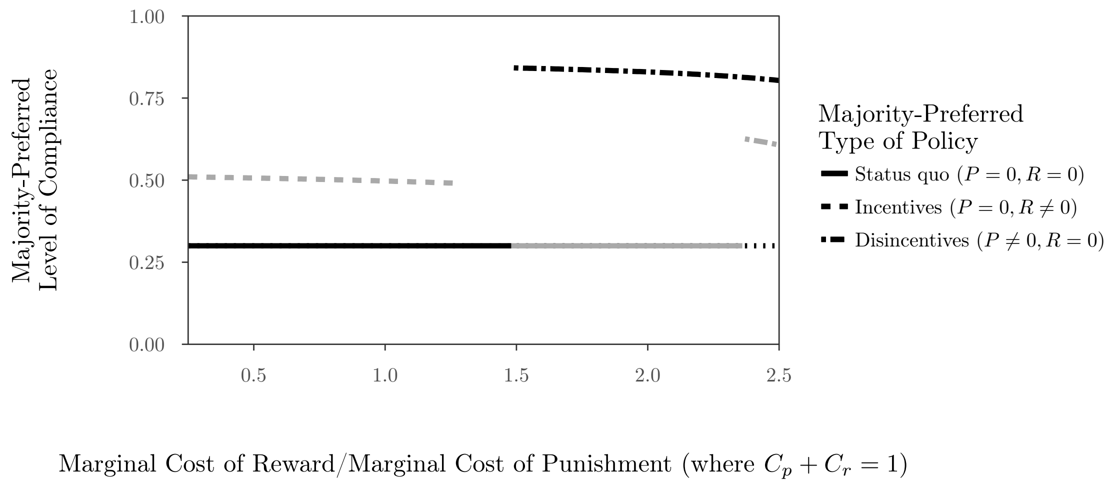
If $\hat{W} \geq W'$*, such that the marginal benefit of compliance under* $\hat{W}$ *is weakly higher than under* W *for all levels of compliance, and if* $\hat{\Gamma}^{**} < \Gamma_0$*, then* $\Gamma^{**} < \hat{\Gamma}^{**} < \Gamma_0$*, and* $\theta^{**} \leq \hat{\theta}^{**}$*.*

(b) *Let* $(\hat{\Gamma}^{**}, \hat{\theta}^{**})$ *be the Condorcet winning policy under* $\hat{F}$*.*

If $\hat{F} \leq F$*, such that the distribution of valuations under* $\hat{F}$ *is an upwards shift of the distribution under* F*, then if* $\Gamma^{**}, \hat{\Gamma}^{**} < \Gamma_0$*, then* $\hat{\Gamma}^{**} \geq \Gamma^{**}$ *and* $\hat{\theta}^{**} \geq \theta^{**}$*.*

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

Figure 6: The effect of decreasing the marginal cost of disincentives relative to the marginal cost of incentives on the median voter's most-preferred level of compliance and type of policy



Notes: The dotted line represents the status quo level of compliance, Γ_0. The gray lines correspond to the social planner's optimal level of compliance and type of policy. The ratio of marginal cost coefficients, C_r/C_p, is increasing along the horizontal axis. The restriction that $C_p + C_r = 1$ facilitates visual comparison but is not a restriction that applies more broadly.

C Proofs from Section 7: Introducing Unaffected Subpopulations

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 $(\Gamma^{\ell*}_{c,p}, p)$ be the policy that maximizes $W((1-\lambda)\Gamma) - (1-\lambda)(1-\Gamma)F^{-1}(1-\Gamma) - C_p((1-\lambda)\Gamma)$ and $(\Gamma^{\ell*}_{nc,r}, r)$ 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 $\Gamma^{\ell*}_{c,p} > \Gamma^{\ell*}_{nc,r}$.

Let the Condorcet winning policy under the functions W, F, C_p, and C_r be given by $(\Gamma^{\ell*}, \theta^{\ell*})$. It is the case that $(\Gamma^{\ell*}, \theta^{\ell*}) \in \{(\Gamma^{\ell*}_{c,p}, p), (\Gamma_0, \phi), (\Gamma^{\ell*}_{nc,r}, r)\}$.

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

It must be that $(\hat{\Gamma}^{\ell*}, \hat{\theta}^{\ell*}) \in \{(\Gamma^{\ell*}_{c,p}, p), (\Gamma_0, \phi), (\Gamma^{\ell*}_{nc,r}, r)\}$.

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 $\hat{\Gamma}^{\ell*} \geq \Gamma^{\ell*}$.

(b) *Let* $(\hat{\Gamma}^{\ell*}, \hat{\theta}^{\ell*})$ *be the Condorcet winning policy under* $\hat{F}$*.*

It must be that $(\Gamma^{\ell*}, \theta^{\ell*}) \in \{(\Gamma^{\ell*}_{c,p}, p), (\Gamma_0, \phi), (\Gamma^{\ell*}_{nc,r}, r)\}$*.*

If $\hat{F} \leq F$*, such that the distribution of valuations under* $\hat{F}$ *is an upwards shift of the distribution under* F*, and if* $\hat{\theta}^{\ell*}, \theta^{\ell*} \neq \phi$*, then* $\hat{\Gamma}^{\ell*} \geq \Gamma^{\ell*}$*.*

Proof of Corollary 2'. This follows directly from Proposition 3 and the discussion in Section 7. ■