Listen to the market, hear the best policy decision, but don't always choose it.*

David Reinstein† and Joon Song‡

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Abstract

Real-world policymakers want to extract investors' private information about a policy's likely effects by "listening to" asset markets. However, this brings the risk that investors will profitably "manipulate" prices to steer policy. We model the interaction between a policymaker and an informed (profit-seeking) investor who can buy/short-sell an asset from uninformed traders. We characterize when the investor's incentives do not align with the policymaker's, implying that to induce truth-telling behavior the policymaker must commit to sometimes ignoring the signal (as revealed by the investor's behavior driving the asset's price). This implies a commitment to executing the policy with a probability depending on the asset's price. We develop a taxonomy for the full set of relationships between private signals, asset values, and policymaker welfare, characterizing the optimal indirect mechanism for each case. We find that where the policymaker is ex-ante indifferent, she commits to sometimes/never executing after a *bad* signal, but always executes after a *good* signal. Generically, this "listening" mechanism leads to higher (policymaker) welfare then ignoring the signals. We discuss real-world evidence, implications for legislative processes, and phenomena such as "trial balloons" and "committing political capital".

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†Department of Economics, University of Essex, drein@essex.ac.uk

‡corresponding author, Department of Economics, Sungkyunkwan University, joonsong.econ@gmail.com

1 Introduction

There are realms where we expect key informed private individuals to know more than policymakers about the impacts of a potential policy. If assets are publicly traded and markets are efficient aggregators of information we might expect policymakers to use these to determine the best policies.

For example, we might consider a trade agreement, new copyright law, or education policy, as aiming to increase the productivity or long run profits of some sector. We can also consider policies designed to increase consumer surplus or government revenue by *reducing* rents in some industry, e.g, health-care reform and the insurance, drug, and hospital industries. In either case, key private players and managers in these sectors may have considerable private information about the likely effect of each policy.

Consider the following scenario. Suppose that at a precise point in time a specific new policy is formulated, or becomes relevant, that was not previously considered. Assume that it is common knowledge that the policymaker (henceforth "the PM") will execute the policy if the asset's price goes in the "right" direction tomorrow. Suppose the policy is designed to boost profits, but the PM is not sure if it will do so. We say that the policy is "good" when it will increase the PM's welfare, and we say it is "bad" otherwise.[1] If investors receive a *signal* that the policy is good they may buy the asset, causing its traded price to increase, convincing the PM to execute the policy. On the other hand, if the signal suggests that the policy is bad they might not buy the asset (or may short sell it), the asset's price will not increase, and the PM will not execute the policy. Here, for either signal, the movement in the asset price is justified by the ultimate policy choice.

This may also work when the good policy *reduces* the assets' value.[2] For example, a policy may be intended to reduce excess insurance company profit, but its true effect may not be known.[3]

[1]Obviously, the PM's incentives may or may not be aligned with the public interest; this central issue of public choice is out of the scope of this paper.

[2]Our model does not require that the policy's *goal* directly involves its effect on an industry or an asset's value; we simply consider particular *alignments*, as discussed below. An exogenous factor, e.g., the progress of technology or the potential supply of some natural resource, may happen to determine both whether a policy will be successful for the PM and whether a particular asset is profitable.

[3]For example, the USA's 2010 Affordable Care Act included an individual mandate and subsidies to purchase insurance as well as the establishment of "insurance exchanges" with regulations intended to reduce prices through

Here, the PM announces a policy. If the price of insurance company shares declines the next day she will execute the policy, and the market's reaction is justified. If the price does not decrease the PM will not execute the policy and again the market's (non-) reaction is justified.

However, unlike in the above scenarios, the interests of the PM and the asset holder may not align. For example, although the PM wants the policy to be executed if and only if it is *good*, the asset holder may always want the policy to be executed, or he may *never* want it to be executed.[4] Thus an asset holder might seek to hide his signal from the PM and thus "manipulate" the asset price. However, the party with inside information need not be the asset holder, and even asset holders may be able sell off their holdings. In our preferred model, we consider the decisions of an *Informed Investor* (henceforth $\mathcal{II}$) who interacts with an individual *Uninformed Trader* (henceforth "UT"), or equivalently, a number of uninformed traders.[5]

Nonetheless, even where incentives are not naturally aligned, the PM may still be able to extract information from $\mathcal{II}$ if she can make a binding commitment to execute (or to not execute) the policy with some minimum probability regardless of $\mathcal{II}$'s actions.[6] Both types of commitment change $\mathcal{II}$'s incentives through two channels. First, they can reduce (or increase) the effect of the $\mathcal{II}$'s action on the probability the policy is executed, hence reducing or increasing the asset's relative expected

encouraging competition and transparent pricing. It was widely assumed the mandate would have a side effect of boosting insurance company profits, while the exchanges and regulations were meant to counter this. Presumably policymakers hoped in net to reduce (or at least not increase) insurance company profits, but opponents of the bill argued that would be a "giveaway" to the insurance industry.

[4]For example, a solar energy firm may want a massive public subsidy for research and development, as it will almost certainly be profitable for this firm. However, the PM may only find it worthwhile if it leads to dramatic breakthroughs, which would lead both to extremely large profits for the firm and large social benefits.

[5]If your eyes see $\mathcal{II}$ as the Roman numeral "two" you can think of him as a "type $\mathcal{II}$" investor, in comparison to the "type I" uninformed trader "UT". We will occasionally refer to him as just "$\mathcal{II}$" without the article "the" when it sounds better. with no "inherent" interest in the assets' value, who may buy the asset, short sell it, or do nothing. With an endogenous asset price, the relevant "alignment" of incentives is subtle; the $\mathcal{II}$'s incentives will depend on the relative probabilities of each signal as well as the effects of policy on asset values.

[6]In the example just mentioned, the PM might tie her own hands to sometimes execute the R&D subsidy even if, after announcing the policy being considered, the solar energy firm's share price do not increase dramatically. She may also (or instead) commit to sometimes *not* executing it even if the share price *does not* increase dramatically after the announcement.

value after each action. Second, if these probabilistic commitments are common knowledge, they will also affect the ex-ante expected returns to the asset, and hence increase or decrease the price the $\mathcal{II}$ must pay the UTs for the asset. If the $\mathcal{II}$ can short sell the asset, these effects on the initial asset price will have a *double* effect on the relative returns to buying versus short-selling.

Note that we model the $\mathcal{II}$ as a single informed investor, or, equivalently, a set of informed investors who coordinate and can thus drive the market. We do not focus on the case where information is diffusely held.[7]

The mechanisms we propose are indirect ones: the PM does not directly pay the $\mathcal{II}$ as a function of his revealed signal and the outcome. Instead, she uses existing asset markets as a tool, and the efficiency of the mechanism depends on the structure and parameters of the environment. We justify this in the conclusion.

We solve for the entire parameter space of incentive alignments, dividing these up into six intuitive cases, offering an intuitive taxonomy, and motivating these with real world examples. Given ex-ante policy indifference we find that inducing truth-telling behavior and listening to markets is generically strictly preferable for the PM. We find an interesting asymmetry: where the PM is ex-ante indifferent, and where her commitment is common knowledge, she commits to occasionally (or never) executing after a *bad* signal, but she always executes after a *good* signal. Also surprising: allowing the $\mathcal{II}$ to short-sell – giving him a greater set of options – may make implementation harder *or easier* and thus decrease *or increase* the PM's payoff, depending on parameters.

Our work is largely a theoretical benchmark; we consider the case with the maximum potential for manipulation, where $\mathcal{II}$ is a single agent, and describe how the optimal mechanism involves randomization, and define the frontier of what the PM can achieve. Our paper may also be seen as a *normative* policy proposal. However, these considerations may also be reflected in current practices, and decision-makers are already taking *prediction* markets into account (Arrow et al.,

[7]In such a case the informed investors might fail to coordinate on the more efficient equilibrium. Even after a signal that the policy is both *good* and profitable, these investors might refrain from buying the asset, each believing that none of the others will buy, and thus the signal will not be passed to the PM, and the policy may not be executed. We return to this discussion in the conclusion.

2008). Although PMs make policy announcements and float "trial balloons" there is little evidence that they *explicitly* commit to tying policy to asset prices. Still there is anecdotal evidence of some policymaker "market-watching." Legislative processes, policy trials, and "committing political capital" may also enable *listening* and informal conditional commitments, in essence a *purification* of the mixed/behavioral strategy. We expand on this in the conclusion.

Our paper proceeds as follows. Section 2 reviews the literature. We specify our formal model in section 3. In section 4 we give general lemmas and results. We conclude in section 5, focusing on the broader academic and practical policy implications of s, ways in which the model could be extended, and suggestions for empirical work.

2 Literature Review

Previous work has analyzed the relationship between the values of assets in *conventional* markets and the policy predictions of information markets.[8] These papers have also considered the implications of using such analysis to set policy. A more extensive literature has considered the effect of policy announcements on asset prices, and the implications that can be drawn from these through *event studies.* A major concern is that if future policy itself reacts to the market's response to the policy announcement, the market response may be hard to interpret; this has been called the "circularity problem" (Bernanke and Mishkin, 1997; Sumner and Jackson, 2008).

To circumvent this circularity, others have proposed the use of "conditional prediction markets"(Hanson, 2013; Abramowicz, 2004). In such a market one asset takes a value, tied to some outcome, if a policy is executed, another asset takes a value if it is *not* executed, and otherwise trades are canceled. For example, Hahn and Tetlock (2003) consider assets whose values are tied to the level of GDP in the event (or non-event, for the second asset) of a carbon emissions cap, and consider what the difference in these asset prices reveal about the likely effect of such a cap.

However, according to Hahn and Tetlock (2003), "[a] general concern is that information markets

[8] *Information markets* are markets which do not represent direct claims on tangible assets (Wolfers and Zitzewitz, 2006). Our analysis may also apply to corporate policy, in cases where the corporate management may know less about outcomes than the market as a whole. Kau et al. (2008) find that, "on average, managers listen to the market: they are more likely to cancel investments when the market reacts unfavorably to the related announcement."

are susceptible to price manipulation by those with a vested interest in the policy decision"; the other aforementioned authors express similar concerns. Because of this, there are important limits to the use of prediction markets, which tend to be thin and illiquid.[9] When real assets such as firms and physical capital are strongly affected by a policy it may be difficult to make prediction markets large enough to deter manipulation. Furthermore, if the main impact of a policy is only known by a single individual or a coordinated group with the ability to heavily invest or short sell (or with a strong direct interest in the outcome) then bringing large numbers of other uninformed traders into the prediction market will not deter manipulation.

It may be more effective for policymakers to learn from the movement of *real* large-scale asset markets and from real investment decisions when a policy is announced, explicitly recognizing (and perhaps publicizing) the connection between the probability of executing the policy and the movement in the asset prices. In this context policymakers could explicitly take into account the incentive for manipulation and use randomized execution to induce truth-telling. As we discuss below, the potential to deter "market manipulation" may rely on the ability of a policymaker to make binding commitments to a *random* policy execution mechanism. Our paper explicitly formalizes and models this problem.

A few recent papers consider the potential for market manipulation in related contexts. Hanson and Oprea (2009) has some similarities to ours, but is fundamentally different in its aims and assumptions. These authors model a market microstructure with noise traders, potentially informed traders, a competitive market maker, and a thin prediction market. As in our model they have a single rational "manipulator"; however, in contrast to us they assume he has a specific preference over the market price or over "the beliefs of neutral observers influenced by the price." In other words, their manipulator is essentially a "noise trader" who has a specific goal unrelated to the asset's true value. In contrast, our $\mathcal{II}$ seeks only to make a *profit* off of the policy outcome he induces.[10]

[9] Sumner and Jackson (2008) note that conditional and prediction markets are likely to be thin and hence unreliable, arguing government subsidies to trading are needed to combat this.

[10] Our model differs in other important ways. Our $\mathcal{II}$ has unique private information; they assume a large number of traders who can pay a cost to learn about the asset's true value and about the manipulator's preferred price. Another difference: we explicitly model the policy choice.

2.1 Empirical work and examples

There are several recent cases in which policymakers seem to have listened to the market, or where others have suggested that they could or should have done so.

Breinlich (2011) examined stock market reactions to the 1989 Canada-United States Free Trade Agreement (CAFTA). He found that "increases in the likelihood of ratification led to stock market gains of exporting firms relative to non-exporters", and used this to impute increased "expected per-period profits of exporters by around 6-7% relative to non-exporters."

During the debate over the US Affordable Care Act, Milani (2010) tracked the stock returns of health insurance companies against a prediction market security whose payoff was tied to the inclusion of the "public option" in the bill. He concluded, "the results reveal the market expectation of a negative effect of the public option on the value of health insurance companies." Friedman (2009) performed event studies on pharmaceutical firms' share prices as they introduced new drugs, comparing the implied profitability of (low versus high Medicare share) drugs before and after the introduction of the Medicare Part D prescription drug benefit. He used this to impute that the bill would lead to $205 billion in additional drug company profits.

Wolfers and Zitzewitz (2006) presented evidence, in the context of the Iraq war in the 2000's, that spot and futures market oil (and equity index option) prices moved in line with a prediction market for a security that paid off if Saddam Hussein were removed from power by a certain date.[11] They used this to estimate the distribution of investors' beliefs for the impact of the war on the economy, imputing "a substantial probability of an extremely adverse outcome."

As Wolfers and Zitzewitz (ibid) argue, the above sort of evidence be used to "better understand the consequences of a prospective policy decision ... [and] to inform decision-making in real time." In light of the above evidence, the public option might have been scrapped, the drug benefit repealed or reformed, the Iraq war reconsidered, and the CAFTA agreement reinforced or cancelled (depending on whether PMs thought the gains were large enough).

The Pentagon also attempted to use markets to predict geopolitical risks. The Defense Advanced Research Projects Agency proposed introducing a policy market that in the Summer of 2003; some

[11] They interpret this as reflecting the probability of a US attack on Iraq in 2002-2003.

claimed these involved "terrorism futures". However, the project was cancelled, allegedly in light of concerns that bad actors might themselves invest, commit terrorist acts, and profit from this (Hanson, 2005).[12]

Poland's 2011-2012 experience seems to be a particularly clear-cut example of policy responding to the market's reaction. In November 2011, Polish PM Donald Tusk announced a new tax on copper and silver. Share prices of KGHM (which controls all of Poland's copper production) fell by 14% on the day of the announcement and a further 9.7% in the next session. On January 3, 2012 the Finance Ministry lowered this proposed tax rate after negative reactions from the Economy and Treasury ministries and from the company, which argued the tax would make output at one of its three mines inviable. Economy Minister Waldemar Pawlak explicitly mentioned the share price reaction in his criticism.[13]

3 Model

In this section, we describe the primitives of our model, the economy in which investors and policymakers interact, and we discuss our maintained assumptions. We next introduce the asset market and justify the assumptions of our model; in particular (i) the timing of information, and in our preferred specification (ii) an endogenous initial asset value and (iii) allowing short-selling. We give a general characterization of the $\mathcal{II}$'s and PM's optimization problems and incentive compatibility constraints, and present some general results and lemmas.

We give some notation. The state is denoted by $s \in S$. There is an informed investor "II", who receives a binary signal, $\sigma \in \{\gamma, \beta\}$, in which γ is the *good* signal and β is the bad signal. The signal is correlated with the state of the world $s \in \{G, B\}$, i.e., the *good* state and the *bad* state (these

[12]This would be a distinct form of manipulation from our discussion; such concerns involve *physical actions* taken in order to manipulate *markets*; we are considering *financial* transactions and investments made in order to influence *policy* (which in turn influences asset values). We assume that the PM does not derive welfare from the investments; if these "investments" are acts of terrorism this is obviously the PM's concern.

[13]Pawlak: "If the tax had been more clearly presented during the prime minister's expose, there would be less unrest and less fluctuation in KGHM's share value. Now we have to prepare [the new tax] properly so that it benefits the state but doesn't kill KGHM" (http://www.wbj.pl/article-57461-deputy-pm-criticizes-copper-tax.html, accessed on 1 Jan. 2014)

states reflect the welfare consequences of a policy, as formalized below). $P(s,\sigma)$ represents the joint probability over (s,σ), and $P(s|\sigma)$ is the conditional probability of s given σ. The unconditional probabilities are $P(s) := \sum_{\sigma\in\{\gamma,\beta\}} P(s,\sigma)$ and $P(\sigma) := \sum_{s\in\{G,B\}} P(s,\sigma)$.[14]

3.1 Timing and policymaker's objective function

Timing:

1. Nature chooses the state of the world, $s \in \{G, B\}$.

2. The PM commits to probabilities of execution $q(\hat{\sigma}) \in (0,1)$ as a function of the signal to be revealed $\hat{\sigma} \in \{\gamma,\beta\}$. These commitments are publicly observed or deduced by all parties.

3. $[t = 0]$ The initial asset price A_0 is formed by the expectation of one or more Uninformed Traders (henceforth, UTs). They are willing to sell or "commit to buy" a total of one unit at this price.

4. The $\mathcal{II}$ receives signal σ and chooses $i \in \{b, nb, sh\}$; respectively, buying one unit, doing nothing, or short selling one unit. The $\mathcal{II}$'s *action* becomes observable to the PM (through its impact on the asset price), sending a signal $\hat{\sigma}$ to the PM.

5. The PM executes the policy with the pre-committed probability $q(\hat{\sigma})$, where $\hat{\sigma} = \sigma$ in a truth telling equilibrium.

6. $[t = 1]$. Payoffs are realized.

We consider this to be a useful representation of the real world. Suppose we had alternately assumed that the $\mathcal{II}$ got the signal *before* $t = 0$, and all agents could anticipate the policy that would be considered at time $t = 1$, A_0 would incorporate the $\mathcal{II}$'s signal. In such a case it would be unclear *when* the PM should look for a discrete jump in the asset price reflecting the policy announcement. Our preferred interpretation of the timing is the following. Although the policy is

[14] Although we restrict the set of states and the set of signals to be two elements, we could easily extend the current setup into many states and many possible signals.

not a complete surprise, (e.g., it might have long been known that the government would pursue a prescription drug plan in 2007), the policy is multi-dimensional, nuanced, and detailed. There is a random element to the PM's choice of policy details; the "listening" pertains to the effect of this. The PM chooses from a potentially infinite set with commonly known statistical properties.[15] The chosen policy will be "good" with probability $P(\gamma)$, etc., as described above. *Only after* the $\mathcal{II}$ knows the chosen policy, he can use his inside information to learn about the policy's likely effects. We denote this as "$\mathcal{II}$ receives signal σ."

PM's payoff: The PM either executes a policy (denoted $p = e$) or does not (denoted $p = ne$). The PM's payoff with the policy choice p and the state s is $W(p, s)$. Note that the investment decision i is not in the PM's objective function. We assume that the PM wants to execute the policy if and only if the true signal is γ; i.e., γ represents the "good news" about the policy. Formally,

Assumption 1 *(i)* $\sum_s P(s|\gamma)W(e,s) > \sum_s P(s|\gamma)W(ne,s)$, *(ii)* $\sum_s P(s|\beta)W(e,s) < \sum_s P(s|\beta)W(ne,s)$.

With probabilistic execution of the policy $\langle q(\gamma), q(\beta)\rangle$, (implicitly assuming the PM has deduced the true signals) the PM's expected payoff is:

$$\Omega(q(\gamma), q(\beta)) := \sum_{s,\sigma} P(s,\sigma)\Big[q(\sigma)W(e,s) + (1 - q(\sigma))W(ne,s)\Big].$$

For later use, we re-write the PM's payoff in terms of gains/losses from execution in either state:

$$\begin{aligned} &\sum_{s,\sigma} P(\sigma,s)W(ne,s) + q(\gamma)P(\gamma)(\mathbb{E}W(e|\gamma) - \mathbb{E}W(ne|\gamma)) + q(\beta)P(\beta)(\mathbb{E}W(e|\beta) - \mathbb{E}W(ne|\beta)) \\ =&\sum_{s,\sigma} P(\sigma,s)W(ne,s) + q(\gamma)P(\gamma)\underbrace{\Delta W(\gamma)}_{(+)} + q(\beta)P(\beta)\underbrace{\Delta W(\beta)}_{(-)} \end{aligned} \tag{1}$$

where we define $\mathbb{E}W(p|\sigma) := \sum_s P(s|\sigma)W(p,s)$ and $\Delta W(\sigma) := \mathbb{E}W(e|\sigma) - \mathbb{E}W(ne|\sigma)$.

By Assumption 1 the second term is positive, and the third term is negative. Thus, as long as the incentive compatibility constraints (described in section 3.3) are satisfied so that the $\mathcal{II}$ reveals the true signal, the PM wants to maximize $q(\gamma)$ and minimize $q(\beta)$.

As a benchmark, we assume that before learning the signal the PM is indifferent between executing the policy and not executing it.

[15]The idea that the specific policy could not have been predicted may be justified as in models of incomplete information.

Assumption 2 *The policymaker is ex-ante indifferent between policies* $< q(\gamma) = 1, q(\beta) = 1 >$ *and* $< q(\gamma) = 0, q(\beta) = 0 >$*, i.e.,*[16]

$$\sum_s P(s)W(e,s) = \sum_s P(s)W(ne,s) \quad i.e., \quad \Delta W(\gamma)P(\gamma) + \Delta W(\beta)P(\beta) = 0.$$

This indifference assumption implies that changes to $q(\beta)$ and $q(\gamma)$ have equal and opposite direct effects on PM's welfare (holding the $\mathcal{II}$'s behavior constant).

3.2 Asset market and the informed investor's payoff

The asset's fundamental value, $A_1(p,s)$, represents the discounted stream of future earnings from the asset; this will depend on the state and the policy. At the end of the interaction, at time $t = 1$, after the state and the policy decision become common knowledge, the asset's price will equal its fundamental value.[17]

Determination of A_0: We could have alternately assumed that the initial asset price A_0 is exogenous, i.e., not affected by $q(\gamma)$ and $q(\beta)$. Instead, we assume it is based on the expected outcomes in light of the conditional probabilities of execution and the unconditional probabilities of each signal. We argue that the latter assumption is more reasonable and relevant.[18] Suppose A_0 were exogenous, and the parameters were such that (e.g.) holding the asset is profitable on average given the announced values of $\langle q(\gamma), q(\beta)\rangle$. If one takes an arbitrary value of A_0, the UTs could be systematically "fooled" and make negative profits in expectation. To avoid this contradiction of rational expectations, we assume that conditional probabilities are correctly anticipated. (The results would be equivalent if we alternatively allowed these probabilities to *not* be correctly anticipated but assumed they are publicly announced before A_0 is set.)

[16]The equivalence of the two conditions is derived by the following.

$$\Delta W(\gamma)P(\gamma) + \Delta W(\beta)P(\beta) = 0 \Leftrightarrow P(\gamma)(\mathbb{E}W(e|\gamma) - \mathbb{E}W(ne|\gamma)) + P(\beta)(\mathbb{E}W(e|\beta) - \mathbb{E}W(ne|\beta)) = 0$$

$$\Leftrightarrow P(\gamma)\mathbb{E}W(e|\gamma) + P(\beta)\mathbb{E}W(e|\beta) = P(\gamma)\mathbb{E}W(ne|\gamma) + P(\beta)\mathbb{E}W(e|\beta) \Leftrightarrow \sum_s P(s)W(e,s) = \sum_s P(s)W(ne,s)$$

[17]We assume that no earnings accrue from the asset until after time $t = 1$; this is without loss of generality.

[18]The results of the model with exogenous A_0 are available by request.

Other possible justifications for an exogenous A_0 do not seem reasonable or relevant to our empirical examples.[19] Thus we assume that at time $t = 0$ the asset's initial price A_0 is determined by the expectations of the UTs before they potentially learn the signal σ, allowing them to depend on the PM's probabilistic commitments. I.e., $A_0 := A_0(q(\gamma), q(\beta))$.

We further assume that the signal and the state are *specific* to the policy, i.e., if the policy is *not* executed the asset's value does not depend on the state:

Assumption 3

$$A_1(ne) := A_1(p = ne, s = G) = A_1(p = ne, s = B).$$

Thus, the expectation of $A_1(ne)$ is invariant to the signal (and state), i.e., $\mathbb{E}A_1(ne|\sigma) = A_1(ne)$ for any $\sigma \in \{\gamma, \beta\}$.

Using this, we derive the initial asset price:

$$\begin{aligned} A_0(q(\gamma), q(\beta)) =& P(\gamma)q(\gamma)\sum_s P(s|\gamma)A_1(e, s) + P(\beta)q(\beta)\sum_s P(s|\beta)A_1(e, s) \\ & + [P(\gamma)(1 - q(\gamma)) + P(\beta)(1 - q(\beta))]A_1(ne) \\ =& P(\gamma)q(\gamma)[\mathbb{E}A_1(e|\gamma) - A_1(ne)] + P(\beta)q(\beta)[\mathbb{E}A_1(e|\beta) - A_1(ne)] + A_1(ne) \\ =& q(\gamma)P(\gamma)\Delta A_1(\gamma) + q(\beta)P(\beta)\Delta A_1(\beta) + A_1(ne), \end{aligned} \tag{2}$$

where we define $\mathbb{E}A_1(e|\sigma)$ – the expected value of the asset conditional on execution and signal, and $\Delta A_1(\sigma)$ – the expected benefit of execution (relative to non-execution) to an asset-holder given signal σ, as

$$\mathbb{E}A_1(e|\sigma) := \sum_s P(s|\sigma)A_1(p = e, s), \text{and } \Delta A_1(\sigma) := \mathbb{E}A_1(e|\sigma) - A_1(ne).$$

[19]Two possible justifications: (i) If only the $\mathcal{II}$ could profit from holding the asset at $t = 1$ (e.g., through his own production process) and he holds all the bargaining power, then A_0 would be priced at cost, regardless of the q's. However, this would imply that the PM could only identify the signal if she could identify *who* the $\mathcal{II}$ was *in advance* and identify his precise choice, a difficult proposition. (ii) If the policy was considered a zero-probability event, and the policy as well as the q functions were announced to the $\mathcal{II}$'s before being publicly announced, or the $\mathcal{II}$'s could react to this information before the UTs, then A_0 might also be unaffected by the q's; it also seems unlikely that the PM could orchestrate this. Furthermore, neither of these scenarios seem to reflect the empirical cases we describe.

Note that the price A_0 does not depend on the signal, as the signal is not common knowledge at $t = 0$.

$\mathcal{II}$'s payoffs: $\mathcal{II}$'s payoff is his net return from buying or short selling the asset. We assume that he can buy the first unit at price A_0 before his action is detected, and the price rises to A_1. (Even if we change the size of this first unit, our results will not change.) If he chooses to buy at time $t = 0$, setting $i = b$, he pays A_0 to the UT, and earns the asset's fundamental value A_1 at $t = 1$. Thus, for either policy choice $p \in \{e, ne\}$ and for either signal $s \in \{G, B\}$,

$$V(p, s, i = b) = A_1(p, s) - A_0.$$

If he short sells at time $t = 0$ (i.e., setting $i = sh$), he gets paid A_0 by the UT, and then must buy the asset at its fundamental value at $t = 1$. Thus, holding the policy constant, the payoff from short selling is the negative of the payoff from buying, i.e.,

$$V(p, s, i = sh) = A_0 - A_1(p, s) = -V(p, s, i = b).$$

If the $\mathcal{II}$ does nothing at time $t = 0$ (i.e., setting $i = nb$), he neither pays nor receives anything at $t = 0$ and neither owns nor owes the asset at time $t = 1$; thus

$$V(p, s, i = nb) = 0.$$

As we show in Appendix A.5, either buying or short selling will yield non-negative profits for $\mathcal{II}$. Thus he will never strictly prefer to "do nothing", if short selling is allowed (note that we assume no administrative costs to transactions). He will be indifferent only for a knife edge case.[20]

We next define $\mathcal{II}$'s expected payoff from buying when he receives signal σ and takes the action that leads the PM to believe the signal was $\hat{\sigma}$ (henceforth, we will say "his action reports $\hat{\sigma}$"; note that $\hat{\sigma} = \sigma$ in a truth-telling mechanism):

$$\begin{aligned}\mathbb{E}V(i = b|\sigma, \hat{\sigma}) &= \sum_s P(s|\sigma)[q(\hat{\sigma})V(e, s, b) + (1 - q(\hat{\sigma}))V(ne, s, b)] \\ &= q(\hat{\sigma})[\mathbb{E}V(e|\sigma) - \mathbb{E}V(ne)] + \mathbb{E}V(ne) = q(\hat{\sigma})[\mathbb{E}A_1(e|\sigma) - \mathbb{E}A_1(ne)] + \mathbb{E}A_1(ne) - A_0(q(\gamma), q(\beta)) \\ &= q(\hat{\sigma})\Delta A_1(\sigma) + A_1(ne) - A_0(q(\gamma), q(\beta)). \qquad (3)\end{aligned}$$

[20] In policy considerations one might want to consider investors who own an asset that is affected by the policy but which they can not sell without large administrative costs. We save this for future work.

In other words, when the $\mathcal{II}$'s signal is σ and his action reports $\hat{\sigma}$, his expected payoff from buying is $q(\hat{\sigma})\Delta A_1(\sigma)$, the expected increase in asset value given the true and reported signals, plus the baseline value under non-execution $A_1(ne)$, less the cost of buying the share $A_0(q(\gamma), q(\beta))$.

When the $\mathcal{II}$'s signal is σ and the PM believes it was $\hat{\sigma}$, the $\mathcal{II}$'s profit from short selling is

$$\mathbb{E}V(i = sh|\sigma, \hat{\sigma}) = -q(\hat{\sigma})\Delta A_1(\sigma) - A_1(ne) + A_0(q(\gamma), q(\beta)) = -\mathbb{E}V(i = b|\sigma, \hat{\sigma}). \tag{4}$$

Expanding $A_0(q(\gamma), q(\beta))$, equations 3 and 4 become:

$$\mathbb{E}V(i = b|\sigma, \hat{\sigma}) = q(\hat{\sigma})\Delta A_1(\sigma) - [q(\gamma)P(\gamma)\Delta A_1(\gamma) + q(\beta)P(\beta)\Delta A_1(\beta)], \tag{5}$$

$$\mathbb{E}V(i = sh|\sigma, \hat{\sigma}) = -\mathbb{E}V(i = b|\sigma, \hat{\sigma}) = -q(\hat{\sigma})\Delta A_1(\sigma) + q(\gamma)P(\gamma)\Delta A_1(\gamma) + q(\beta)P(\beta)\Delta A_1(\beta). \tag{6}$$

The first term on the right hand side of (5) and (6) is the expected gain or loss in asset value from probabilistic execution given the true and reported signals. The bracketed terms are the *ex-ante* expectation of this gain or loss, i.e., $A_0 - A_1(ne)$. Holding constant the signal sent, the gain from shorting is the loss from buying and vice-versa. With a truth-telling mechanism, buying and short selling will send *opposite* signals.

To be concise, we denote the informed investor who has received signal σ by $\mathcal{II}(\sigma)$.

3.3 Incentive compatibility constraints

For $\mathcal{II}$'s behavior to be truth-telling, he must prefer to buy whenever he sees a good signal and short sell whenever he sees a bad signal, or vice versa. Formally, the PM may interpret $i = b$ and $i \neq b$ (i) as the investor having received signal γ and β respectively, or (ii) as the investor having received signal β and γ respectively. Thus, there are two possible sets of incentive compatibility constraints.

Set 1 (Buy if and only if the signal is γ):

Here, the PM interprets $i = b$ as $\mathcal{II}$ having received γ. The IC constraints when short selling is allowed are:

$$q(\gamma)\Delta A_1(\gamma) + A_1(ne) - A_0(q(\gamma), q(\beta)) \geq -q(\beta)\Delta A_1(\gamma) - A_1(ne) + A_0(q(\gamma), q(\beta)), \tag{IC_{11}}$$

$$-q(\beta)\Delta A_1(\beta) - A_1(ne) + A_0(q(\gamma), q(\beta)) \geq q(\gamma)\Delta A_1(\beta) + A_1(ne) - A_0(q(\gamma), q(\beta)). \tag{IC_{12}}$$

The first constraint ensures the $\mathcal{II}$ prefers to buy when he gets signal γ; the second constraint ensures he prefers to short sell when he gets signal β. In other words, the first constraint deters $\mathcal{II}(\beta)$ from mimicking $\mathcal{II}(\gamma)$ with signal γ, and the second deters $\mathcal{II}(\gamma)$ from mimicking $\mathcal{II}(\beta)$.

We rearrange IC_{11} for intuition (the intuition for IC_{12} is similar):

$$\underbrace{q(\gamma)\Delta A_1(\gamma)}_{(i)} - \underbrace{(q(\gamma)\Delta A_1(\gamma)P(\gamma) + q(\beta)\Delta A_1(\beta)P(\beta))}_{(ii)}$$
$$\geq \underbrace{-q(\beta)\Delta A_1(\gamma)}_{(i)} + \underbrace{(q(\gamma)\Delta A_1(\gamma)P(\gamma) + q(\beta)\Delta A_1(\beta)P(\beta))}_{(ii)}$$

On each side of the above inequality, (i) represents the $\mathcal{II}$'s expectation of the gain (or loss) in the asset's value given the signal he is sending, and (ii) is the ex-ante expected gain (or loss) in the asset's value.

Note that if short-selling is not allowed, the right-hand side will be zero.

Inequalities IC_{11} and IC_{12} can also be written as:

$$\Delta A_1(\gamma)\Big[q(\beta)\Big(1 - 2P(\beta)\frac{\Delta A_1(\beta)}{\Delta A_1(\gamma)}\Big) + q(\gamma)(1 - 2P(\gamma))\Big)\Big] \geq 0, \qquad (IC'_{11})$$
$$\Delta A_1(\beta)\Big[q(\gamma)\Big(1 - 2P(\gamma)\frac{\Delta A_1(\gamma)}{\Delta A_1(\beta)}\Big) + q(\beta)(1 - 2P(\beta))\Big)\Big] \leq 0. \qquad (IC'_{12})$$

Set 2 (Buy if and only if the signal is β):

Here, the PM interprets $i = sh$ as $\mathcal{II}$ having received γ. The incentive compatibility constraints when short sale is allowed are:

$$-q(\gamma)\Delta A_1(\gamma) - A_1(ne) + A_0(q(\gamma), q(\beta)) \geq q(\beta)\Delta A_1(\gamma) + A_1(ne) - A_0(q(\gamma), q(\beta)), \qquad (IC_{21})$$
$$q(\beta)\Delta A_1(\beta) + A_1(ne) - A_0(q(\gamma), q(\beta)) \geq -q(\gamma)\Delta A_1(\beta) - A_1(ne) + A_0(q(\gamma), q(\beta)), \qquad (IC_{22})$$

The first constraint ensures that $\mathcal{II}(\gamma)$ prefers buying to short selling; the second constraint ensures that $\mathcal{II}(\beta)$ prefers short selling to buying. Without short-selling, the left (right) side of the first (second) inequality is zero. These constraints can be motivated and simplified as in set 1.

Note that Sets 1 and 2 are precisely the converse of each other, i.e., both constraints are derived by multiplying both sides by negative one, but holding the inequality signs the same.

Remark 1: We do not allow the PM to set direct payments after any combination of revealed signal and realized state. However, $A_0(q(\gamma), q(\beta))$ plays a role similar to a direct payment in the standard mechanism model with transferable utility. As shown in the $\mathcal{II}$'s payoff (e.g., $q(\gamma)\Delta(A) + A_1(ne) - A_0(q(\gamma), q(\beta)))$, the choice of randomized policy execution $\langle q(\gamma), q(\beta)\rangle$ changes how much the $\mathcal{II}$ has to pay/receive (i.e., $A_0(q(\gamma), q(\beta)))$. To be more specific, if $\mathcal{II}$ chooses to buy, his net payoff is $q(\gamma)\Delta(A) + A_1(ne) - A_0(q(\gamma), q(\beta))$, and he has to pay $A_0(q(\gamma), q(\beta))$. On the other hand, if an $\mathcal{II}$ chooses to short sell, his net payoff is $-q(\gamma)\Delta(A) - A_1(ne) + A_0(q(\gamma), q(\beta))$, and he receives $A_0(q(\gamma), q(\beta))$ for the short sale. However, the difference from the direct payment in the standard mechanism design literature is that $A_0(q(\gamma), q(\beta))$ depends on the allocation of a non-money commodity (i.e., the randomized allocation $\langle q(\gamma), q(\beta)\rangle$ in our model).

Remarks 2: Our paper can also be compared with the literature on costly signaling models following Spence (1973): $\mathcal{II}$ sends a costly signal by buying/short-selling the asset, and upon observing $\mathcal{II}$'s action, the PM chooses execution/non-execution. The most obvious difference between our model and costly signaling models is that the PM commits to the probability of execution, $(q(\gamma), q(\beta))$. However, that is not the only difference. The strategy $q(\sigma)$ after observing signal σ also influences $A_0(q(\gamma), q(\beta))$, i.e, the equilibrium play determines the payoffs (including out-of-equilibrium payoffs). Thus, our model is not easily comparable, requiring two extensions to the costly signaling model.

4 Analysis

In this section, we characterize the optimal probabilistic commitment $\langle q(\gamma), q(\beta)\rangle$, which maximizes the PM's welfare without breaking the incentive compatibility constraints of the $\mathcal{II}$s.

4.1 General results

With the aforementioned commitment $\langle q(\gamma), q(\beta)\rangle$, the PM's problem is:

$$\max_{0\le q(\cdot)\le 1} \sum_{s,\sigma} P(\sigma, s)\Big[q(\sigma)W(e, s) + (1 - q(\sigma))W(ne, s)\Big]$$

$$s.t. \text{ IC set 1 } (IC_{11}, IC_{12}) \text{ or IC set 2 } (IC_{21}, IC_{22}). \tag{7}$$

We define the *first best policy*, *blind policies*, and an *incentive-constrained optimal policy.*

Definition 1 (First best policy) $\langle q(\gamma) = 1, q(\beta) = 0\rangle$ *is the* first best policy.

Definition 2 (Blind policy) $\langle q(\gamma), q(\beta)\rangle$ *with* $q(\gamma) = q(\beta)$ *is a* blind policy.

Definition 3 (Incentive-constrained optimal policy) *An* incentive-constrained optimal policy *solves the PM's maximization problem (7).*

Considering expression (1), the first best policy trivially maximizes the policymaker's welfare since $\Delta W(\gamma) > 0$ and $\Delta W(\beta) < 0$. However, it may not be feasible since it may not be incentive compatible, as we show later.

A PM who employs a blind policy *does not listen to markets* as the signal does not alter her probability of executing the policy, i.e., $q(\gamma) = q(\beta)$. However, this policy is always incentive compatible (i.e., it satisfies one of the two sets of constraints, so that it leads $\mathcal{II}$ to take a distinct action after each signal).

Proposition 4 *Any blind policy is incentive compatible (i.e., it satisfies one of the two sets of incentive compatibility constraints).*

Proof. See Appendix. ∎

With a blind policy, UTs assume it occurs equally often when its effect on the asset is more favorable and when it is less favorable (or harmful). This is reflected in the market price. $\mathcal{II}$ will thus buy if he gets the signal suggesting that execution will be *more* favorable to the asset's value, and short sell otherwise. (If, nongenerically, the effect on the asset's value is the same in either state he is always indifferent but his behavior is truth-telling in equilibrium by the standard argument.)

Lemma 5 *The incentive-constrained optimal* $\langle q(\gamma), q(\beta)\rangle$ *satisfies* $q(\gamma) \geq q(\beta)$.

Proof. Considering expression (1) in light of the PM's indifference (Assumption 2), $q(\gamma) < q(\beta)$ implies that the sum of the last two terms in expression (1) is negative; while $q(\gamma) = q(\beta)$ (i.e., *not listening to markets*) implies this sum is zero. Thus we must have $q(\gamma) \geq q(\beta)$. ∎

Lemma 5 implies that hearing a truthful signal and then making the *wrong* policy decision most of the time is worse than not listening at all.

Proposition 6 *The incentive-constrained optimal policy satisfies* $1 = q(\gamma) \geq q(\beta)$.

Proof. IC constraints are written as $Cq(\gamma) \gtreqless q(\beta)$; as can be seen from a small rearrangement of (IC'_{11}) and (IC'_{12}) (Note again that Sets 1 and 2 are identical except for the direction of the inequalities). If the constraint is $Cq(\gamma) \geq q(\beta)$, the first best $q(\gamma) = 1$ and $q(\beta) = 0$ trivially satisfies the constraint as long as $C \geq 0$. If $C < 0$, $q(\gamma) = q(\beta) = 0$ is the only possible solution. However, we have shown in the proof for Proposition 4 that for all $\tilde{q} \in [0, 1]$, $\tilde{q} = q(\gamma) = q(\beta)$ is incentive compatible in the relevant constraint set. Thus, $Cq(\gamma) \geq q(\beta)$ must not be in the relevant set since only $q(\gamma) = q(\beta) = 0$ is incentive compatible, while the other $\tilde{q} = q(\gamma) = q(\beta)$ is not.

Thus, when an incentive compatibility constraint is binding, it must be expressed as:

$$Cq(\gamma) \leq q(\beta).$$

Since $q(\gamma) \geq q(\beta)$ from Lemma 5, $C \leq 1$ must be the case (if not, we have a contradiction: $Cq(\beta) \leq Cq(\gamma) \leq q(\beta)$ with $C > 1$). If $C = 1$, $q(\gamma) = q(\beta) = 1$ is a trivial solution since $q(\gamma) \geq q(\beta)$.If the constraint is satisfied with $Cq(\gamma) = q(\beta) < 1$ where $C < 1$, then PM could do better by increasing $q(\gamma)$ by ϵ and increasing $q(\beta)$ by a smaller amount $C\epsilon$. ∎

This asymmetric result is consistent with asymmetry of the problem; the PM "naturally" wants $q(\beta) = 0$ and $q(\gamma) = 1$, and zero and one do not have symmetric properties. Note that Proposition 6 holds even when short sale is not allowed (see Remark in Appendix A.3.1). However, this proposition depends critically on the assumption of *endogenous* A_0; as we demonstrate in section 4.5, if A_0 were exogenous, this proposition would not hold.

Given that $q(\gamma) = 1$, the only variable we have to deal with is $q(\beta)$. With two constraints for each set and a single choice variable $q(\beta)$, it is trivial that at most only one constraint binds generically.

Corollary 7 *For a given set, at most one of the two incentive compatibility constraints will bind.*

Note again that (IC_{11}) and (IC_{12}) are identical to (IC_{22}) and (IC_{21}) respectively, except that the inequalities are reversed. With $k \neq i$ and $\ell \neq j$, if (IC_{ij}) holds as an equality with a certain $\langle q(\gamma), q(\beta)\rangle$, then $(IC_{k\ell})$ holds as an equality with $\langle q(\gamma), q(\beta)\rangle$.

We can write down (IC_{11}) and (IC_{12}) as follows:

$$\underbrace{[q(\gamma) + q(\beta)]\Delta A_1(\gamma)}_{(a)} \underbrace{-2\mathbb{E}(\Delta A_1)}_{(b)} \geq 0 \geq \underbrace{[q(\gamma) + q(\beta)]\Delta A_1(\beta)}_{(a)} \underbrace{-2\mathbb{E}(\Delta A_1)}_{(b)}, \tag{8}$$

where $\mathbb{E}(\Delta A_1) := A_0 - A_1(ne)$.

Considering the expression above, we can divide the net payoffs to $\mathcal{II}(\gamma)$ from the truth-telling action (relative to an action that falsely sends signal $\hat{\beta}$) into "policy-driven" and "expectation-driven" (relative) payoffs. For set 1, the policy-driven payoff, labeled "(a)" above, represents the change in the asset's value after buying the asset and sending a good signal – i.e., the return for an "asset owner" – less the *negative of* the change in the asset's value after short selling and sending a bad signal – the return for an "asset *ower*". The expectation-driven payoffs, labeled "(b)" above, represent the cost of purchasing the asset less the income from short selling it, i.e., (the negative) of twice the initial price; these prices are affected by the UT's *expectations.*

Clearly, the set given by the above two constraints is non-empty only if $\Delta A_1(\gamma) \geq \Delta A_1(\beta)$. Similarly, Set 2 (i.e., (IC_{21}) and (IC_{22})) can be expressed as:

$$[q(\beta) + q(\gamma)]\Delta A_1(\beta) - 2\mathbb{E}(\Delta A_1) \geq 0 \geq [q(\beta) + q(\gamma)]\Delta A_1(\gamma) - 2\mathbb{E}(\Delta A_1) \tag{9}$$

The set is non-empty only if $\Delta A_1(\beta) \geq \Delta A_1(\gamma)$. Note that $\Delta A_1(\gamma) \geq \Delta A_1(\beta)$ and $\Delta A_1(\beta) \geq \Delta A_1(\gamma)$ are exclusive (excepting the knife-edge case) and exhaustive, and that even blind policies are incentive compatible. Thus,generically, only one set can be implemented, so the relative size of $\Delta A_1(\gamma)$ and $\Delta A_1(\beta)$ fully determines which set of incentive compatibility constraints are used. From this, we derive the following proposition.

Proposition 8 *The PM induces Set 1 ("buy only if good") if $\Delta A_1(\gamma) > \Delta A_1(\beta)$ and Set 2 ("buy only if bad") if $\Delta A_1(\gamma) > \Delta A_1(\beta)$.*

Note that proposition 8 holds even if short-selling is not allowed (in that case, although both sets may be implementable, only one can be implemented profitably; see remarks in appendix A.3.1).

Finally, we show that the PM always does better by listening to the market.

Proposition 9 *The incentive-constrained optimal policy is generically superior to blind policies.*

Proof. See appendix A.1.2. ∎

The proof works by showing that generically, for incentive-constrained optimality, $q(\beta) < 1$. This is then combined with Proposition 6 to show that generically $1 = q(\gamma) > q(\beta)$, which is superior to a blind policy.

In other words, listening is generically better then not listening. Thus – given our assumption that the signal is informative of the true state – ex-ante indifference implies that the PM is willing to make commitment $\langle q(\gamma), q(\beta)\rangle$ in order to learn the signal. (In some cases, no commitment will be necessary, i.e., $\langle q(\gamma) = 1, q(\beta) = 0\rangle$ may be optimal.) Note that proposition 9 will hold whether or not short selling is allowed (see Remark in Appendix A.3.1).

4.2 Characterizing binding constraints

As we show by characterizing all cases below, for particular values of $\Delta A_1(\gamma)$,$\Delta A_1(\beta)$, if one IC constraint binds where $P(\gamma) > \frac{1}{2} > P(\beta)$, it will not bind where $P(\gamma) < \frac{1}{2} < P(\beta)$. This is shown in figure 1 below. The (potentially) binding constraint depends here on whether $P(\beta) > P(\gamma)$ or vice versa. In general, the $\mathcal{II}$ may be able to profit from either buying or shorting, i.e., from taking the action that, in expectation conditional on the signal, and knowing that the PM will follow him, is more profitable. This is because he has an information advantage over the UTs in knowing which signal he is sending the PM, and thus what the PM will likely do. His informational advantage and his profit will tend to be greater (from truth-telling) for a given signal the less likely this signal is, i.e., the lower is $P(\sigma)$, as it will induce a less likely policy outcome, hence a larger profit. This offers intuition for a policymaker: in general she should be more concerned about an informed investor trying to fake the *less* likely signal. Figure 1 describes the binding constraints in each region. (Note that $\emptyset$ means that no constraint is binding, i.e., the PM achieves the first best).

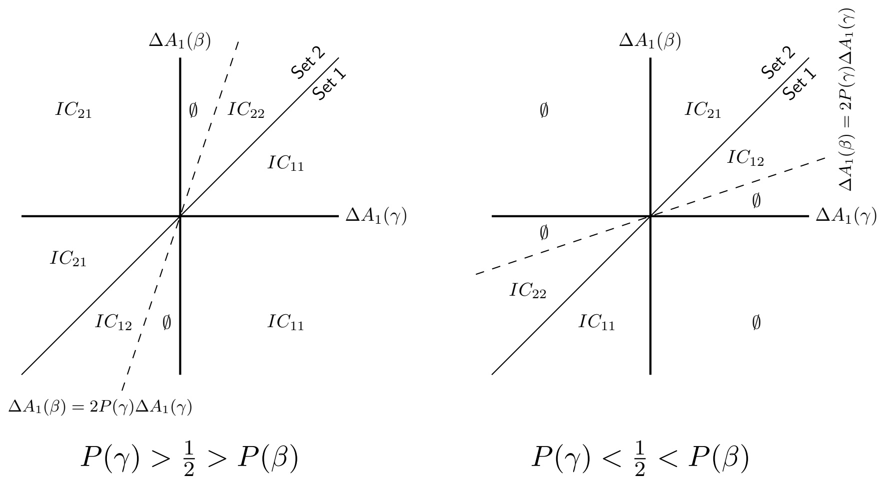


Figure 1: Allowing short-selling

4.3 Full characterization: Six cases

We divide the parameter sets into six cases in terms of the policy's effect on the asset's value after each signal: (i) $\Delta A_1(\gamma) > \Delta A_1(\beta) > 0$, (ii) $\Delta A_1(\beta) > \Delta A_1(\gamma) > 0$, (iii) $\Delta A_1(\beta) > 0 > \Delta A_1(\gamma)$, (iv) $0 > \Delta A_1(\beta) > \Delta A_1(\gamma)$, (v) $0 > \Delta A_1(\gamma) > \Delta A_1(\beta)$, and (vi) $\Delta A_1(\gamma) > 0 > \Delta A_1(\beta)$. This classification, along with a taxonomy we will explain, is displayed in figure 2.

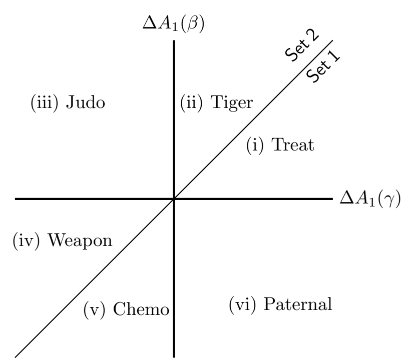


Figure 2: Taxonomy of incentive alignment between PM and an *asset-owner*

We can interpret these six cases in terms of the alignment of incentives of the PM and the *asset* *owner*. To give insight, we solve for case 1 in detail; the other five cases are solved more concisely, with derivations in the appendix. Results are summarized in figure 3 in section 4.4.

4.3.1 Case (i), "A Treat": $\Delta A_1(\gamma) > \Delta A_1(\beta) > 0$, *i.e., the asset's value increases when the policy is executed, more so with the good signal.*

This policy represents a *treat* for the asset-owner; execution will always increase the asset's value, but from the PM's perspective, it is only worth "buying this treat" where the signal suggests if it will be *very* beneficial to the asset holder. This case may reflect a trade policy that involves costly concessions for the government but will be worth executing if it boosts a particular export sector by a sufficient amount; cf. Breinlich (2011). Alternatively, it might reflect a public research and development funding plan that will certainly stimulate some new inventions and raise profits somewhat, but will require dramatic results to justify its large costs. A macroeconomic stimulus or a bank or international bailout may have similar properties.[21]

Proposition 8 implies that Set 1 is relevant, and Proposition 6 implies $q(\gamma) = 1$. Since $\Delta A_1(\gamma) > 0$ and $\Delta A_1(\beta) > 0$, we can rewrite IC'_{11} and IC'_{12} substituting these out:

$$q(\beta)\Big(1 - 2P(\beta)\frac{\Delta A_1(\beta)}{\Delta A_1(\gamma)}\Big) - (1 - 2P(\beta)) \geq 0, \quad \Big(1 - 2P(\gamma)\frac{\Delta A_1(\gamma)}{\Delta A_1(\beta)}\Big) - q(\beta)(1 - 2P(\gamma)) \leq 0$$

[Condition 1: $P(\gamma) = \frac{1}{2} = P(\beta)$] Then the two constraints become:

$$q(\beta)\Big(1 - \frac{\Delta A_1(\beta)}{\Delta A_1(\gamma)}\Big) \geq 0, \quad \Big(1 - \frac{\Delta A_1(\gamma)}{\Delta A_1(\beta)}\Big) \leq 0$$

Thus we can reduce $q(\beta)$ to zero, and the incentive-constrained optimal policy achieves the first best, $\langle q(\gamma) = 1, q(\beta) = 0\rangle$.

[21]Extending the model, suppose the $\mathcal{II}$ is a large bond speculator, the PM is the European Union, and the policy is a package guaranteeing bonds against default, requiring austerity measures, and giving loans and aid to Greece. The default risk and the effectiveness of the policy are both uncertain. The bond holders (and Greek leaders) might prefer the EU to provide the maximal aid, but it may not be worth the cost to the EU. The EU could "announce consideration" of a policy, implying a certain conditional probability of execution, and see how the markets react. The *direction* of the likely effect is known (bonds will increase in value and yields will decline) but the magnitude of the effect will determine whether to execute the policy.

[Condition 2: $P(\gamma) > \frac{1}{2} > P(\beta)$**]** Suppose $P(\gamma) > \frac{1}{2} > P(\beta)$. Then the above is simplified into:

$$q(\beta)\underbrace{\frac{1-2P(\beta)\frac{\Delta A_1(\beta)}{\Delta A_1(\gamma)}}{1-2P(\beta)}}_{(a)} \geq 1, \quad \underbrace{\frac{1-2P(\gamma)\frac{\Delta A_1(\gamma)}{\Delta A_1(\beta)}}{1-2P(\gamma)}}_{(b)} \geq q(\beta)$$

Note that the second inequality is reversed as it was divided by a negative number.

Both (a) and (b) are larger than 1. Since the PM wants to decrease $q(\beta)$ as much as she can, the only relevant (i.e., binding) constraint is the first one. Thus we conclude:

$$\text{For } P(\gamma) > 1/2 > P(\beta),\ \left\langle q(\gamma) = 1, q(\beta) = \frac{1-2P(\beta)}{1-2P(\beta)\frac{\Delta A_1(\beta)}{\Delta A_1(\gamma)}}\right\rangle.$$

[Condition 3: $P(\gamma) < \frac{1}{2} < P(\beta)$**]** Then the ICs are simplified into:

$$q(\beta)\frac{1-2P(\beta)\frac{\Delta A_1(\beta)}{\Delta A_1(\gamma)}}{1-2P(\beta)} \leq 1, \quad \frac{1-2P(\gamma)\frac{\Delta A_1(\gamma)}{\Delta A_1(\beta)}}{1-2P(\gamma)} \leq q(\beta)$$

The first constraint is irrelevant irrespective of the sign of $\frac{1-2P(\beta)\frac{\Delta A_1(\beta)}{\Delta A_1(\gamma)}}{1-2P(\beta)}$ as the PM wants to minimize $q(\beta)$ (note that $q(\beta) = 0$ trivially satisfies the first constraint). If $\frac{1-2P(\gamma)\frac{\Delta A_1(\gamma)}{\Delta A_1(\beta)}}{1-2P(\gamma)}$ is negative, then the second constraint is also irrelevant; the optimal solution is $\langle q(\gamma) = 1, q(\beta) = 0\rangle$. If $\frac{1-2P(\gamma)\frac{\Delta A_1(\gamma)}{\Delta A_1(\beta)}}{1-2P(\gamma)}$ is positive, it is smaller than 1. Then the second constraint is relevant, i.e., the second constraint binds, and we derive the optimal solution $\left\langle q(\gamma) = 1, q(\beta) = \frac{1-2P(\gamma)\frac{\Delta A_1(\gamma)}{\Delta A_1(\beta)}}{1-2P(\gamma)}\right\rangle$.

To summarize, the optimal policy interprets the $\mathcal{II}$'s buying as signal γ and his not buying as signal β. The optimal incentive-constrained optimal policy is:

$$\text{For } P(\gamma) < 1/2 < P(\beta),\ \left\langle q(\gamma) = 1, q(\beta) = \max\left(0, \frac{1-2P(\gamma)\frac{\Delta A_1(\gamma)}{\Delta A_1(\beta)}}{1-2P(\gamma)}\right)\right\rangle,$$

$$\text{for } P(\gamma) > 1/2 > P(\beta),\ \left\langle q(\gamma) = 1, q(\beta) = \frac{1-2P(\beta)}{1-2P(\beta)\frac{\Delta A_1(\beta)}{\Delta A_1(\gamma)}}\right\rangle,$$

$$\text{and for } P(\gamma) = 1/2 = P(\beta),\ \langle q(\gamma) = 1, q(\beta) = 0\rangle, \text{i.e., the first best.}$$

Note that $P(\gamma) = 1/2 = P(\beta)$ implies the first best, $\langle q(\gamma) = 1, q(\beta) = 0\rangle$ for all cases, so we will not mention it further.

Remark 3 [Binding constraints and signal probabilities]: Consider why the second constraint (IC_{12}) does not bind where $P(\gamma) > P(\beta)$. Suppose these probabilities, and suppose the policy is at the first-best $\langle q(\gamma) = 1, q(\beta) = 0\rangle$. Here, an $\mathcal{II}(\beta)$ type will want to short sell and deter execution. The UTs believe that the policy is executed "most of the time"; thus deterring execution yields the larger information advantage or "surprise". $\mathcal{II}(\beta)$ can profit from this information advantage in proportion to $\Delta A_1(\gamma)$, as when he short-sells the UTs compensate him for their predicted execution after the *good* signal.

In contrast, if $\mathcal{II}(\beta)$ were to buy and induce execution, this would bring only the smaller $\Delta A_1(\beta)$ in ex-post profit while to buy the asset he would have to compensate the UTs for their expectation of asset gains from execution under the good signal, paying them $P(\gamma)\Delta A_1(\gamma)$.

Now consider why (IC_{12}) *may* bind where $P(\gamma) < P(\beta)$. Here if the policy were first-best the UTs would believe it would be executed less then half of the time; thus *inducing* execution yields the larger surprise, an information advantage of $1 - P(\gamma)$. On the other hand, the (ex-post) gain from inducing execution here is only proportional to $\Delta A_1(\beta)$ but he must pay the UT's for the asset in proportion to $\Delta A_1(\gamma)$; the "asymmetric asset gain" hurts him here. In contrast, by short-selling and deterring execution he is inducing a smaller surprise but will not have to pay for the asymmetric asset gain. These two effects go in the opposite direction, and where the "larger surprise" advantage outweighs the "asymmetric asset gain" cost – i.e., where i.e., where $2P(\gamma) < \frac{\Delta A_1(\beta)}{\Delta A_1(\gamma)}$ – then IC_{12} will bind.

Note that derivations for cases 2-6 are in appendix A.2.

4.3.2 Case (ii), "Tiger": $\Delta A_1(\beta) > \Delta A_1(\gamma) > 0$, i.e., *the asset's value increases when the policy is executed, less so with the good signal.*

Consider a benefit program such as the USA's Medicare part D that is expected to be somewhat profitable for the drug industry, but will also yield other public benefits. However, depending on the true market structure and true prospects for innovation, the drug industry might be able to use this to reap excess profits at the expense of consumers (see Friedman, 2009).

Solution: The PM will use Set 1, i.e., will induce the $\mathcal{II}$ to short sell under the good signal, and buy under the bad signal. She will do this by setting:

$$\left\langle\ q(\gamma)=1, q(\beta)=\frac{1-2P(\beta)}{1-2P(\beta)\frac{\Delta A_1(\beta)}{\Delta A_1(\gamma)}}\right\rangle \text{ if } P(\gamma)<1/2<P(\beta),$$

$$\text{and setting } \left\langle\ q(\gamma)=1, q(\beta)=\max\left(0,\frac{1-2P(\gamma)\frac{\Delta A_1(\gamma)}{\Delta A_1(\beta)}}{1-2P(\gamma)}\right)\right\rangle \text{ if } P(\gamma)>1/2>P(\beta).$$

The contrast between cases (i) and (ii) offers real-world lessons. The choice of which type of behavior to try to induce depends on the relative gains to the asset under the good or bad policy. If the asset does better when the policy is *bad*, policymakers may want to get informed investors to buy only if the policy is bad, and then will have to promise to execute the policy with some probability anyway.

4.3.3 Case (iii), "Judo": $\Delta A_1(\beta) > 0 > \Delta A_1(\gamma)$, i.e., *the asset's value increases when policy is executed under the bad signal, and decreases when it is executed under the good signal.*

For this case the dimension of interaction between the policymaker and the industry is largely zero-sum, with few mutual gains or losses. The policy may be a reform of taxes or regulation that intends to be harsher and more punitive. However, it may backfire, perhaps if the firm finds loopholes, and may actually increase profits (hence the term "Judo").

Solution: The PM will use Set 2 and induce the $\mathcal{II}$ to short sell under the good signal, and buy under the bad signal, by setting:

$$\text{For } P(\gamma)<1/2<P(\beta),\ \langle q(\gamma)=1, q(\beta)=0\rangle.$$

$$\text{For } P(\gamma)>1/2>P(\beta),\ \left\langle q(\gamma)=1, q(\beta)=\frac{1-2P(\beta)}{1-2P(\beta)\frac{\Delta A_1(\beta)}{\Delta A_1(\gamma)}}\right\rangle.$$

4.3.4 Case (iv), "Weapon": $0 > \Delta A_1(\beta) > \Delta A_1(\gamma)$, i.e., *the asset's value decreases when the policy is executed, more so with the good signal.*

This describes a policy intended (or expected) to severely reduce profits. Perhaps these profits are seen as monopoly or monopsony rents, and thus reducing them may increase consumer surplus.

There may be some cost to administering this policy. It may require a severe regulatory burden so it will only be worth doing if it has a major "trust busting" effect. Advocates of this policy may argue that it will reduce "excess profiteering" by monopolists and oligopolists. Opponents may argue it will have little effect on rents, as the oligopolists will find ways to evade it, yet it will lead to large bureaucratic costs and negative unintended consequences for consumers. This policy is a "weapon" worth using only if it is fierce enough.

Solution: The PM will use Set 2 and induce the $\mathcal{II}$ to short sell under the good signal and buy under the bad signal, by setting:

$$\text{For } P(\gamma) > 1/2 > P(\beta),\ \left\langle q(\gamma) = 1, q(\beta) = \frac{1 - 2P(\beta)}{1 - 2P(\beta)\frac{\Delta A_1(\beta)}{\Delta A_1(\gamma)}} \right\rangle,$$

$$\text{and for } P(\gamma) < 1/2 < P(\beta),\ \left\langle q(\gamma) = 1, q(\beta) = \max\left(0, \frac{1 - 2P(\gamma)\frac{\Delta A_1(\gamma)}{\Delta A_1(\beta)}}{1 - 2P(\gamma)}\right)\right\rangle$$

4.3.5 Case (v), "Chemotherapy": $0 > \Delta A_1(\gamma) > \Delta A_1(\beta)$, i.e., ***The asset's value decreases when the policy is executed, more so with the bad signal.***

This may reflect a tax increase or increase in the regulatory burden on industry, but one that is not intended to be excessively burdensome. The Polish mining tax (see section 2.1) offers a good example. This also may reflect a stricter price cap for a regulated industry such as a utility; the government wants to limit profits but not to bankrupt the firm(s). Macroeconomic policy raising interest rates to respond to inflation might be similarly characterized. Like *chemotherapy*, this policy is expected to do some damage, but it is only successful if it does not harm the patient (or asset) too much.

Solution: The PM will use Set 1 and induce the $\mathcal{II}$ to buy under the good signal and short sell under the bad signal, by setting:

$$\text{For } P(\gamma) > 1/2 > P(\beta),\ \left\langle q(\gamma) = 1, q(\beta) = \max\left(0, \frac{1 - 2P(\gamma)\frac{\Delta A_1(\gamma)}{\Delta A_1(\beta)}}{1 - 2P(\gamma)}\right)\right\rangle, \text{and}$$

$$\text{for } P(\gamma) < 1/2 < P(\beta),\ \left\langle q(\gamma) = 1, q(\beta) = \frac{1 - 2P(\beta)}{1 - 2P(\beta)\frac{\Delta A_1(\beta)}{\Delta A_1(\gamma)}} \right\rangle.$$

4.3.6 Case (vi), "Paternalist": $\Delta A_1(\gamma) > 0 > \Delta A_1(\beta)$, i.e., *The asset's value increases when policy is executed under a good signal, and decreases when it is executed after a bad signal.*

This reflects a policy that under some circumstances will have direct or indirect benefits for the industry, and in other cases will hurt the industry. It may be directly designed to benefit the industry, such as a change in regulations meant to deter destructive competition, or allow coordination on an industry-standard. This may apply to patent reform, or to a complicated change in trade agreements or in immigration law. Another policy that is contested in this way is putting limits on CEO pay. This may also reflect policy with other goals, e.g., an educational reform, but which is only seen as worth doing if it happens to help (and not harm) some key industries. This might be called a *paternalist* policy because at best it helps an industry achieve higher profits than they could achieve alone, but at worst it represents a misguided government overreach that hurts the private sector.

Solution: The PM will induce the $\mathcal{II}$ to buy under the good signal and short sell under the bad signal, by setting:

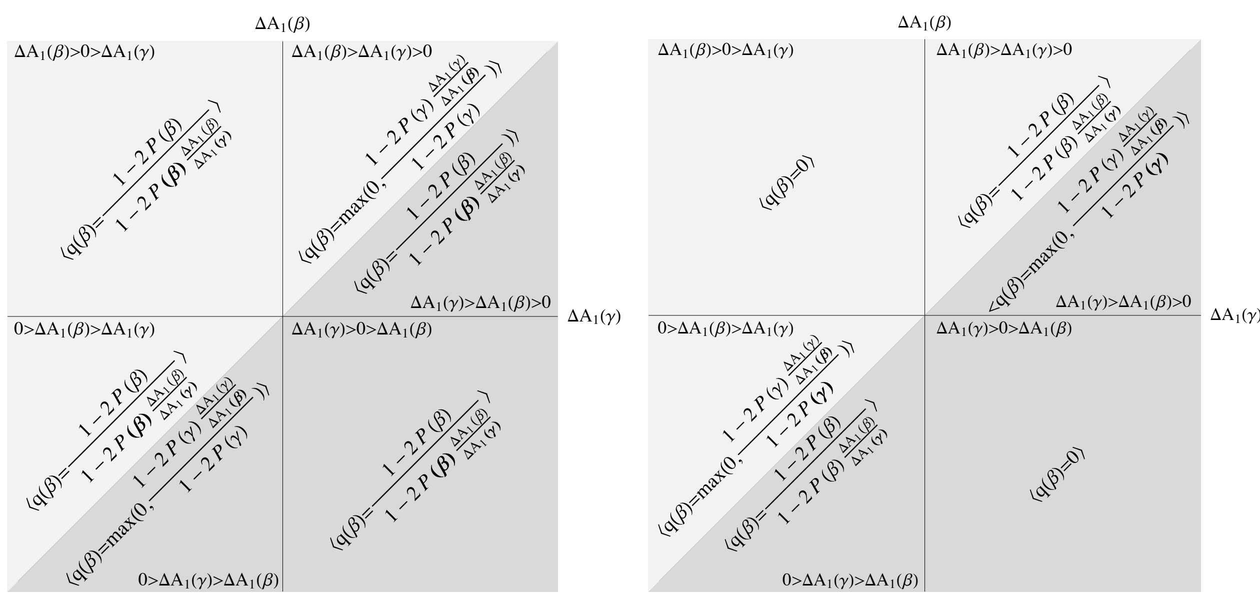
$$\text{For } P(\gamma) > 1/2 > P(\beta),\ \Big\langle q(\gamma) = 1, q(\beta) = \frac{1 - 2P(\beta)}{1 - 2P(\beta)\frac{\Delta A_1(\beta)}{\Delta A_1(\gamma)}}\Big)\Big\rangle.$$

$$\text{For } P(\gamma) < 1/2 < P(\beta),\ \langle q(\gamma) = 1, q(\beta) = 0\rangle.$$

Remark 4: Note that the first best is achieved if the good signal is more likely. This agrees with our standard notion of "aligned incentives": both the government and an asset holder will want the policy executed if and only if it is a good policy. If the asset price A_0 were unaffected by the q functions, this would hold for any value of $P(\gamma)$. With an exogenous A_0 the $\mathcal{II}$ would only care about the impact of the policy on the asset's fundamental value, and incentives would be clearly aligned. He would always want to buy after a good signal, inducing the "good" policy and making a profit on the asset, and would never want to buy after a bad signal. With the endogenous A_0 this is still the case if the good signal is more rare, and thus the information advantage can also be better exploited from inducing execution than from short selling and inducing non-execution. However, if the good signal is the more common one, the "natural" incentives to increase the asset's value and the greater information advantage go in opposite directions, thus $q(\beta)$ may need to be increased to get truthful behavior. A similar insight holds for the symmetric case (iii), i.e., wherever the expected *direction* of the policy impact on the asset depends on the signal. This highlights an insight for policymaker: even if ex-post incentives are aligned, the incentive to buy or short sell an asset may not be.

4.4 Comparison with an alternative model without short sale

We now summarize the optimal policies for all of the cases graphically. Since $q(\gamma) = 1$ whether short sale is allowed or not, we omit the value of $q(\gamma)$ in graphs. We first present the algebraic solutions by region and probabilities $P(\gamma) \gtreqless P(\beta)$; we also illustrate the incentive-constrained optimal policy when short sale is not available to informed investors. The derivation is in appendix A.3.



$P(\gamma) > \frac{1}{2} > P(\beta)$ $\qquad$ $P(\gamma) < \frac{1}{2} < P(\beta)$

Figure 3: Allowing short-selling

Simple intuition might suggest that restricting the tools available to the informed investor, e.g.,

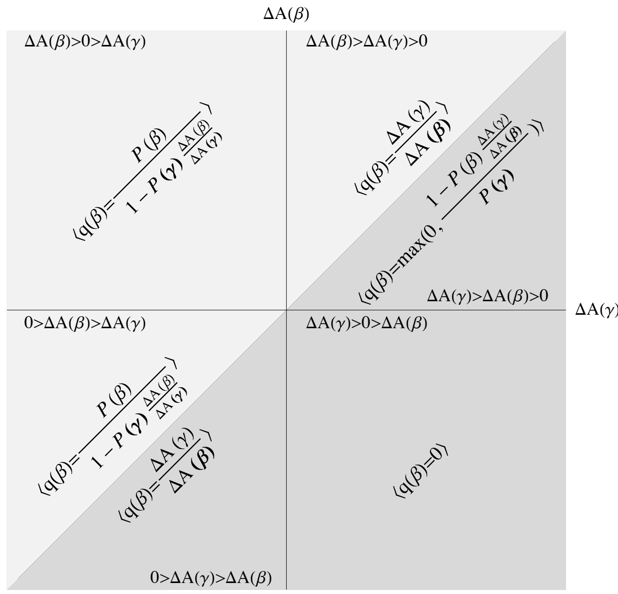
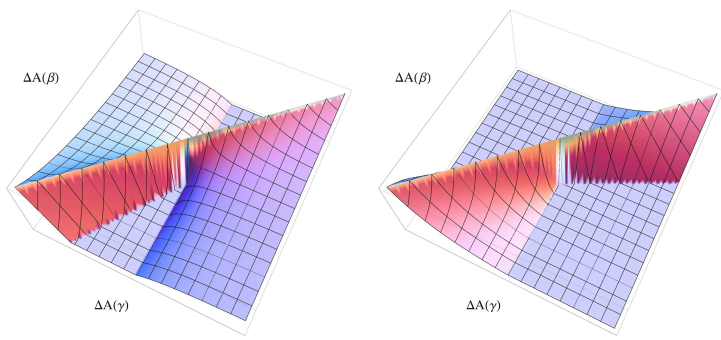


Figure 4: Without short-selling

by forbidding short sale, would make it harder for him to 'manipulate' the policy outcome and conversely, easier to get him to reveal his private information. However, as seen in Figure 3 and 4, sometimes allowing $\mathcal{II}$ to short sell *lowers* the incentive compatible $q(\beta)$ and thus improves the PM's welfare. There are two potentially countervailing effects. First, the potentially profitable short-selling opportunity means $\mathcal{II}$ may not prefer to buy after a good signal. Second, allowing short-selling may make it *easier* to dissuade him from buying after a bad signal.

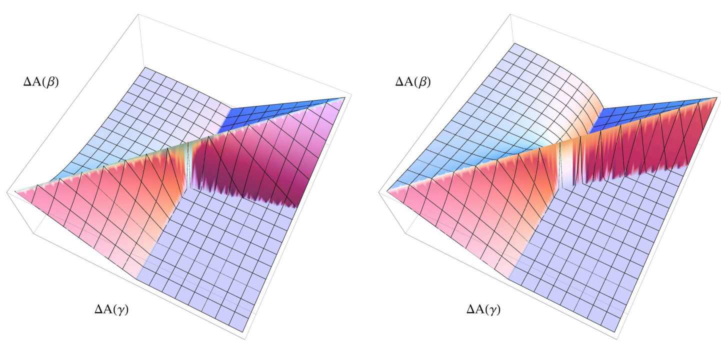
Indeed, it can be easily shown that with $P(\gamma) < P(\beta)$, allowing short sale (weakly) lowers $q(\beta)$ in cases (ii)-(vi). Even in region (i), allowing short sale increases welfare if $\Delta A_1(\beta) \leq P(\beta)\Delta A_1(\gamma)$ or $\frac{1}{2} \geq P(\gamma) \geq \frac{1}{3}$ holds when $P(\gamma) < P(\beta)$. Even when $P(\gamma) > P(\beta)$ is the case, we can find some necessary and sufficient conditions under which allowing short sale improves welfare: $\Delta A_1(\beta) > \frac{1}{2}\Delta A_1(\gamma)$ and $\Delta A_1(\beta) > P(\beta)\Delta A_1(\gamma)$ in region (i), $\Delta A_1(\beta) < 2P(\gamma)\Delta A_1(\gamma)$ in region (ii), $\frac{1}{2} > P(\beta) > \frac{1}{3}$ in regions (iii) and (iv), no condition is required in region (v), and $q(\beta) = 0$ in region (vi) with or without the possibility of short sale. These comparisons are shown in figures 3 and 4. We give comparisons for $(P(\gamma) = 3/4, P(\beta) = 1/4)$ and $(P(\gamma) = 1/4, P(\beta) = 3/4)$ in figures 5 and 6

Although allowing short sale provides a further tool for $\mathcal{II}$'s deviation, it also can provides $\mathcal{II}$ more benefit when he is truthful. Short sale makes both the right-hand side and the left hand side of each incentive compatibility constraint larger; hence, it may become easier (or harder) to enforce truth-telling.



$P(\gamma) = \frac{3}{4} > P(\beta) = \frac{1}{4}$ $\qquad$ $P(\gamma) = \frac{1}{4} < P(\beta) = \frac{3}{4}$

Figure 5: With short-selling



$P(\gamma) = \frac{3}{4} > P(\beta) = \frac{1}{4}$ $\qquad$ $P(\gamma) = \frac{1}{4} < P(\beta) = \frac{3}{4}$

Figure 6: Without short-selling

4.5 Comparison with an alternative model with exogenous A_0 and without short sale

Our above proposition 6 – stating that the PM may set $q(\beta) > 0$ but will always set $q(\gamma) = 1$ – depended on the endogeneity of A_0 in $(q(\gamma), q(\beta))$. To illustrate this point, we show that when A_0 is exogenous, $q(\beta) = 0$ and $q(\gamma) < 1$ is optimal for certain values of the parameters.

We consider one such case as an example. The full case-by-case analysis is available by request. We henceforth use the following notation:

$$\mathbb{E}\, V(p|\sigma) = \sum P(s|\sigma) V(p, s, i = b).$$

We consider a case that resembles case (i) of our preferred model. We assume that an $\mathcal{II}$ who buys gets a profit when a good policy is executed, a lower profit when a bad policy is executed, and sustains a loss when the policy is not executed. (It is trivial to show that these payoffs could arise from a particular assumption over the fixed initial asset price A_0 and the assets' value under each state and policy outcome.) We assume that the investor's payoff satisfies the following.

$$\mathbb{E}\, V(e|\gamma) > \mathbb{E}\, V(e|\beta) > 0 > \mathbb{E}\, V(ne|\sigma) \tag{10}$$

Condition (10) implies that the first set of IC constraints is relevant. Here $\mathcal{II}(\gamma)$ is induced to choose $i = b$, while $\mathcal{II}(\beta)$ must choose $i = nb$. In other words, sending the bad signal means not buying the asset. This requires the following incentive compatibility constraints:

$$\sum_s P(s|\gamma)[q(\gamma)(V(e, s, b)) + (1 - q(\gamma))V(ne, s, b)] \geq 0, \tag{11}$$

$$0 \geq \sum_s P(s|\beta)[q(\gamma)V(e, s, b) + (1 - q(\gamma))V(ne, s, b)]. \tag{12}$$

When $\mathcal{II}(\gamma)$ deviates to *not buy*, he earns nothing; as does $\mathcal{II}(\beta)$ when he tells the truth by not buying ($i = nb$); hence the zero terms on the right (left) side of the first (second) inequality. A similar interpretation applies to the second incentive compatibility constraint.

Set 1 is further simplified into:

$$q(\gamma)[\mathbb{E}\, V(e|\gamma) - \mathbb{E}\, V(ne|\gamma)] \geq -\mathbb{E}\, V(ne|\gamma) \text{ and } -\mathbb{E}\, V(ne|\beta) \geq q(\gamma)[\mathbb{E}\, V(e|\beta) - \mathbb{E}\, V(ne|\beta)]. \tag{13}$$

If the agent does not buy the asset, he no longer cares whether the policy is executed or not. Hence, the PM will set $q(\beta) = 0$, as executing the policy after a bad signal will be costly but does not encourage truth-telling. In other words, under Condition 10, $q(\beta) = 0$; as we show formally below. (Note that the same intuition does not go through in our preferred model with *endogenous* A_0; setting $q(\beta) > 0$ in our preferred model will affect the asset's initial price and thus the $\mathcal{II}$'s relative incentives to buy or short.)

The objective function is:

$$\sum_{s,\sigma} P(\sigma, s)W(ne, s) + q(\gamma)P(\gamma) \underbrace{(\mathbb{E}\, W(e|\gamma) - \mathbb{E}\, W(ne|\gamma))}_{(+)} + q(\beta)P(\beta) \underbrace{(\mathbb{E}\, W(e|\beta) - \mathbb{E}\, W(ne|\beta))}_{(-)}.$$

As $q(\beta)$ is not present in the constraints, the PM must set $q(\beta) = 0$, as $\Delta W(\beta) < 0$ from the previously defined welfare function.

On the other hand $q(\gamma)$ cannot be either 0 or 1: if $q(\gamma) = 1$, then the investor with signal $\sigma = \beta$ always succeeds in deceiving the policymaker, and if $q(\gamma) = 0$, then the policymaker never executes the policy, which implies an inefficiency since the policymaker ignores valuable information. Thus $q(\gamma)$ must be a number between 0 and 1.

We derive the optimal value of $q(\beta)$ in appendix A.4. This yields the optimal policy $\left\langle q(\beta) = 0, q(\gamma) = \frac{1}{\frac{\mathbb{E}\, V(e|\beta)}{-\mathbb{E}\, V(ne|\beta)} + 1} \right\rangle$ under Condition 10, that is, $q(\gamma) < 1$. The PM interprets the $\mathcal{II}$'s buying (not buying) as having received signal γ (signal β).

This demonstrates that (as noted above) with a fixed initial asset price A_0 and no short selling, the PM optimally sets $\langle q(\gamma) < 1,\, q(\beta) = 0\rangle$ for some ranges of parameters.

5 Conclusion

Although politicians often appear to be more concerned with immediate public opinion than with the efficacy of policies, in cases where voters do not have a strong issue identification, performance is what matters.[22] Thus, after floating policy "trial balloons" politicians may listen to both polls

[22] This is likely to hold for technical "hard issues" (Carmines and Stimson, 1980). Fiorina (1978), among others found some evidence for "retrospective voting"; however, there is debate over its explanatory power (see e.g., Fiorina et al., 2003).

and markets.[23]

The ability to listen and conditionally commit, perhaps imprecisely, may be embodied in the political system. In a system with several branches of government, the framers of a constitution could either allow an executive (President or Premier) to execute policy unilaterally, or require her to put a bill to the legislative branch (or directly to the people). Although she cannot precisely set the probability it will be passed after each type of market news she can make the bill more or less palatable the first time she submits it. For example, President Obama could have first submitted his health care bill with public funding of abortion, which presumably would have made it unlikely to pass. If it failed, but the market's reaction appeared favorable, he could then submit a similar bill without the abortion provision. The constitutional and procedural "rules" may affect the extent to which a bill's sponsor can introduce unrelated "riders," the extent to which the bill can be adjusted throughout the process, and the length of time a bill is considered.

The commitment might also take the form of a policy trial, perhaps one with a high probability of a type-I or type-II error. The PM could commit to follow the results of the trial if they are strongly significant in one direction or the other, which may be a small fraction of the time. Here, the PM might not actually expect to learn from the trial; instead she cares more about how the market reacts to the *announcement* of the trial. Where the trial's results are *not* significant, she can follow the signals generated by $\mathcal{II}$'s behavior.

Another commitment strategy is *committing political capital.* A government, political party, or faction may come out in support of a policy, and put their credibility on the line. This may make it costly but not impossible to later vote against the policy if the market reveals a negative signal.[24] This commitment would plausibly have *no effect* on the probability of execution if the market reveals a good signal. This commitment may be made weaker or stronger depending on the number of legislators that are asked to speak strongly in favor of the policy. Suppose there is

[23] Listening to the market is not equivalent to a referendum; the commitments we describe allow the PM to use the market to *extract private information* about the potential results of policies. Unlike referendum voters, traders in the market are "voting" about what they think is profitable, but not necessarily voting for what benefits them as a private citizen.

[24] This cost could come from a loss of reputation for managerial expertise as in Prendergast and Stole (1996) or a simple voter dislike or distrust of inconsistency and "flip-flopping", perhaps signalling untrustworthiness

asymmetric information over these legislators' true preferences or allow other sources of randomness such as revealed public support. A simple model should demonstrate that the likelihood that the bill is passed after a bad signal would increase in the number of legislators committing political capital to the policy.

Generally, a long deliberation permitting amendments and reconsiderations may allow legislators more time and flexibility to listen to the market; "fast-tracking" will limit this. The timeline under which a policy is introduced to the legislative process could also affect its conditional probability of execution after each signal. Suppose the market is expected to reveal its signal(s) about the policy with a known hazard rate. The bill could then be scheduled for a vote on a particular date, implying a certain probability that the (good or bad) signal will have been revealed.

Adding legislator-specific favors and "pork", or unfavorable "poison" to the bill could also alter the conditional probabilities. Suppose that there is uncertainty about legislator's preferences and thus uncertainty over the probability that a bill will pass after either signal (or without a signal). However, some legislators' preferences can be identified: known "swing Democrats" will always support the bill after a *good signal*, but may oppose it after a bad signal. Suppose that offering pork for a legislator's district will raise the probability that she votes for a bill after any signal – this is, of course, as long as she is not already certain to vote for (against) the bill. Offering pork for a swing Democrat will increase $q(\beta)$ without affecting $q(\gamma)$.

As noted, our indirect mechanism does not follow the standard rules. There are reasons why it may not be feasible to set up an explicit mechanism, paying investors for insider information. Such "strange handouts" would likely be politically unpopular. It may be difficult to know which investors have the "accurate" information. The government could try to commit such investors who claim to have information to put money down and take losses if they are wrong, however they may not be able to pay back such losses, and they may be reluctant, or perhaps unable (because of credit constraints) to put money down in advance. The asset markets that exist are already suited to deal with these commitment problems. Secondly, if the government recruited and offered commitments to these "informants" it would still have to carefully monitor what positions the informants take in assets market. They may have outside investments that would undermine the mechanism for truth telling in the explicit "direct payments" mechanism. Therefore, the asset markets will still need to be taken into account. Finally, to the extent that the government could design mechanisms of rewards and punishments on its own, the considerations that will be relevant will be similar to the ones we describe below.

It is possible that for more technical policies and for more technocratic policymakers this will involve explicit randomization. However, we think it will more likely to take the form (and may have already taken the form) of introducing bills and legislation that has differing likelihood of passing, and exploiting the randomness in the political system. We also imagine that, even if policymakers do not explicitly consider the extent to which they should introduce randomness, we offer a framework for thinking about how they can use the market signals to adapt policy. As noted above, we have suggestive evidence that they are already taking into account how the market reacts in formulating legislation and in executing it.

One concern mentioned by Wolfers and Zitzewitz (2006) is that if there are several public and private signals of a policy's efficacy, the interpretation of the difference in the conditional asset's value will depend on all of these, and may be difficult to interpret. E.g., a government may only execute a carbon cap in the event of severe flooding of the Eastern seaboard; hence the conditional expectation of GDP in the event of a carbon cap may also reflect the expectation of the effect this flooding. Thus, introducing exogenous randomness may have an additional benefit: it may help improve the interpretation of market signals even *without* manipulation. Our own modeling does not address this, as we focus on the investor's private signal; this is scope for future work.

Our model could be extended in several ways. Future work might examine a case where the policymaker is seeking to influence *investor* behavior. It may also be interesting to model an investor who has an *inherent* interest, e.g., owning a asset affected by the policy which cannot be sold without costs.

The most valuable extensions will be empirical. Economists should seek to identify and measure the *ways* in which particular asset values will be differentially affected by policies, and how this relates to the policies' welfare consequences. Where a connection is found, economists should also measure the extent to which the information is concentrated in the hands of potential "manipulators." Armed with this information, policymakers may benefit by setting up a "listening process", bearing in mind the implementation concerns we describe. As we describe, they may need to limit the extent to which good or bad news feeds directly into policy, incorporating literal or approximate ex-ante policy commitments.

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A Appendix

A.1 Proofs for Lemmas and Propositions

A.1.1 Proof for Proposition 4

It is trivial that $q(\gamma) = q(\beta) = 0$ is incentive compatible.

Now consider $q(\gamma) = q(\beta) > 0$. Plugging $\tilde{q} = q(\gamma) = q(\beta) > 0$ into (IC'_{11}) and (IC'_{12}), we derive:

$$\tilde{q}\Big[\Delta A_1(\gamma) - 2P(\beta)A_1(\beta) + A_1(\gamma) - 2P(\gamma)A_1(\gamma)\Big] \geq 0 \;\Leftrightarrow\; 2\tilde{q}P(\beta)\Big[\Delta A_1(\gamma) - A_1(\beta)\Big] \geq 0,$$
$$\tilde{q}\Big[\Delta A_1(\beta) - 2P(\gamma)A_1(\gamma) + A_1(\beta) - 2P(\beta)A_1(\beta)\Big] \leq 0 \;\Leftrightarrow\; 2\tilde{q}P(\gamma)\Big[\Delta A_1(\beta) - A_1(\gamma)\Big] \leq 0$$

using $P(\gamma) + P(\beta) = 1$.

Similarly, plugging $\tilde{q} = q(\gamma) = q(\beta) > 0$ into (IC_{21}) and (IC_{22}), we derive:

$$2\tilde{q}P(\gamma)\Big[\Delta A_1(\beta) - A_1(\gamma)\Big] \geq 0, \quad 2\tilde{q}P(\beta)\Big[\Delta A_1(\gamma) - A_1(\beta)\Big] \leq 0.$$

As noted earlier, the two sets are identical except the direction of the inequalities. Set 1 is satisfied if $\Delta A_1(\gamma) \geq \Delta A_1(\beta)$, and Set 2 is satisfied if $\Delta A_1(\gamma) \leq \Delta A_1(\beta)$. Thus a blind policy is incentive compatible in terms of one set of incentive compatibility constraints.

A.1.2 Proof for Proposition 9

To prove this we show that generically, for incentive-constrained optimality, $q(\beta) < 1$. From Proposition 6, this implies generically $1 = q(\gamma) > q(\beta)$, which is superior to a blind policy.

Generically, $\Delta A_1(\gamma) \neq \Delta A_1(\beta)$. (i) Assume $\Delta A_1(\gamma) > \Delta A_1(\beta)$. Suppose that $q(\gamma) = q(\beta) = 1$ non-generically. Then Set 1 becomes: $2P(\beta)\Big[\Delta A_1(\gamma) - A_1(\beta)\Big] \geq 0,\ 2P(\gamma)\Big[\Delta A_1(\beta) - A_1(\gamma)\Big] \leq 0$ as shown in the proof for Proposition 4. We can see that both of these two constraints hold with strict inequality, implying $q(\beta) < 1$ would also satisfy these constraints, and thus $q(\beta) = 1$ must be suboptimal. (ii) Assuming $\Delta A_1(\gamma) < \Delta A_1(\beta)$, we can apply the same logic to the second set of incentive compatibility constraints to derive a contradiction.

A.2 Derivations for cases 2-6

A.2.1 Case ii: $\Delta A_1(\beta) > \Delta A_1(\gamma) > 0$

Proposition 8 implies that Set 2 is the relevant one. Also $q(\gamma) = 1$ from Proposition 6. Since $\Delta A_1(\beta) > \Delta A_1(\gamma) > 0$, we can simplify the two incentive constraints into:

$$q(\beta)\Big(1 - 2P(\beta)\frac{\Delta A_1(\beta)}{\Delta A_1(\gamma)}\Big) - (1 - 2P(\beta)) \leq 0, \quad \Big(1 - 2P(\gamma)\frac{\Delta A_1(\gamma)}{\Delta A_1(\beta)}\Big) - q(\beta)(1 - 2P(\gamma)) \geq 0$$

[Case 1: $P(\gamma) > \frac{1}{2} > P(\beta)$] Then the above is simplified into:

$$q(\beta)\frac{1 - 2P(\beta)\frac{\Delta A_1(\beta)}{\Delta A_1(\gamma)}}{1 - 2P(\beta)} \leq 1, \quad \underbrace{\frac{1 - 2P(\gamma)\frac{\Delta A_1(\gamma)}{\Delta A_1(\beta)}}{1 - 2P(\gamma)}}_{(b)} \leq q(\beta)$$

Clearly, the first constraint is not relevant as the PM wants to minimize $q(\beta)$. If $(b) > 0$, then the solution is $< q(\gamma) = 1, q(\beta) = \frac{1-2P(\gamma)\frac{\Delta A_1(\gamma)}{\Delta A_1(\beta)}}{1-2P(\gamma)} >$. If $(b) \leq 0$, then the second constraint is also irrelevant by the same reason; thus the solution is $< q(\gamma) = 1, q(\beta) = 0 >$. In summary, the solution is:

$$\text{For } P(\gamma) > 1/2 > P(\beta),\ \left\langle q(\gamma) = 1, q(\beta) = \max\left(0, \frac{1 - 2P(\gamma)\frac{\Delta A_1(\gamma)}{\Delta A_1(\beta)}}{1 - 2P(\gamma)}\right)\right\rangle$$

[Case 2: $P(\gamma) < \frac{1}{2} < P(\beta)$]. The incentive compatibility constraints are:

$$q(\beta)\underbrace{\frac{1 - 2P(\beta)\frac{\Delta A_1(\beta)}{\Delta A_1(\gamma)}}{1 - 2P(\beta)}}_{(a)} \geq 1, \quad 1 \geq \underbrace{\frac{1 - 2P(\gamma)}{1 - 2P(\gamma)\frac{\Delta A_1(\gamma)}{\Delta A_1(\beta)}}}_{(b)} q(\beta)$$

Then the second constraint is irrelevant as PM wants to minimize $q(\beta)$. Note $(a) > 1$, so the solution is:

$$\text{For } P(\gamma) < 1/2 < P(\beta),\ \left\langle q(\gamma) = 1, q(\beta) = \frac{1 - 2P(\beta)}{1 - 2P(\beta)\frac{\Delta A_1(\beta)}{\Delta A_1(\gamma)}}\right\rangle.$$

A.2.2 Case iii: $\Delta A_1(\beta) > 0 > \Delta A_1(\gamma)$

Proposition 8 implies that Set 2 is the relevant one. Also $q(\gamma) = 1$ from Proposition 6. Since $\Delta A_1(\beta) > 0 > \Delta A_1(\gamma)$, we can simplify these into:

$$q(\beta)\left(1 - 2P(\beta)\frac{\Delta A_1(\beta)}{\Delta A_1(\gamma)}\right) - (1 - 2P(\beta)) \geq 0, \quad \left(1 - 2P(\gamma)\frac{\Delta A_1(\gamma)}{\Delta A_1(\beta)}\right) - q(\beta)(1 - 2P(\gamma)) \geq 0$$

[Case 1: $P(\gamma) > \frac{1}{2} > P(\beta)$] The above is simplified into:

$$q(\beta)\underbrace{\frac{1 - 2P(\beta)\frac{\Delta A_1(\beta)}{\Delta A_1(\gamma)}}{1 - 2P(\beta)}}_{(a)} \geq 1, \quad \underbrace{\frac{1 - 2P(\gamma)\frac{\Delta A_1(\gamma)}{\Delta A_1(\beta)}}{1 - 2P(\gamma)}}_{(b)} \leq q(\beta)$$

Note that $(a) > 1$ and $(b) < 0$; thus, the second constraint is irrelevant, and the result follows.

$$\text{For } P(\gamma) > 1/2 > P(\beta),\ \left\langle q(\gamma) = 1, q(\beta) = \frac{1 - 2P(\beta)}{1 - 2P(\beta)\frac{\Delta A_1(\beta)}{\Delta A_1(\gamma)}}\right\rangle.$$

[Case 2: $P(\gamma) < \frac{1}{2} < P(\beta)$] The incentive compatibility constraints are:

$$q(\beta)\underbrace{\frac{1 - 2P(\beta)\frac{\Delta A_1(\beta)}{\Delta A_1(\gamma)}}{1 - 2P(\beta)}}_{(a)<0} \leq 1, \quad 1 \geq \underbrace{\frac{1 - 2P(\gamma)}{1 - 2P(\gamma)\frac{\Delta A_1(\gamma)}{\Delta A_1(\beta)}}}_{(b)>0} q(\beta)$$

Note that since $(a) < 0$ and $(b) > 0$ hold, both of the constraints are irrelevant, so the solution is:

$$\text{For } P(\gamma) < 1/2 < P(\beta),\ \langle q(\gamma) = 1, q(\beta) = 0\rangle.$$

A.2.3 **Case iv:** $0 > \Delta A_1(\beta) > \Delta A_1(\gamma)$

Proposition 8 implies that Set 2 is the relevant one. Also $q(\gamma) = 1$ from Proposition 6. Since $0 > \Delta A_1(\beta) > \Delta A_1(\gamma)$, the constraints are simplified into:

$$q(\beta)\Big(1 - 2P(\beta)\frac{\Delta A_1(\beta)}{\Delta A_1(\gamma)}\Big) - (1 - 2P(\beta)) \geq 0, \quad \Big(1 - 2P(\gamma)\frac{\Delta A_1(\gamma)}{\Delta A_1(\beta)}\Big) - q(\beta)(1 - 2P(\gamma)) \leq 0$$

[**Case 1:** $P(\gamma) > \frac{1}{2} > P(\beta)$] The above can be simplified into:

$$q(\beta)\underbrace{\frac{1 - 2P(\beta)\frac{\Delta A_1(\beta)}{\Delta A_1(\gamma)}}{1 - 2P(\beta)}}_{(a)} \geq 1, \quad \underbrace{\frac{1 - 2P(\gamma)\frac{\Delta A_1(\gamma)}{\Delta A_1(\beta)}}{1 - 2P(\gamma)}}_{(b)} \geq q(\beta)$$

Note that $(a) > 1$ and $(b) > 1$; thus, the second constraint is irrelevant, and the result follows.
[**Case 2:** $P(\gamma) < \frac{1}{2} < P(\beta)$] then the IC constraints can be written as:

$$q(\beta)\underbrace{\frac{1 - 2P(\beta)\frac{\Delta A_1(\beta)}{\Delta A_1(\gamma)}}{1 - 2P(\beta)}}_{(a)<1} \leq 1, \quad \underbrace{\frac{1 - 2P(\gamma)\frac{\Delta A_1(\gamma)}{\Delta A_1(\beta)}}{1 - 2P(\gamma)}}_{(b)<1} \leq q(\beta)$$

Since $(a) < 1$, the first constraint is irrelevant. If $(b) < 0$, the second constraint is also irrelevant; and the optimal solution is $< q(\gamma) = 1, q(\beta) = 0 >$. If $0 < (b) < 1$, then the optimal solution is $< q(\gamma) = 1, q(\beta) = \frac{1-2P(\gamma)\frac{\Delta A_1(\gamma)}{\Delta A_1(\beta)}}{1-2P(\gamma)} >$. So the result follows.

A.2.4 **Case v:** $0 > \Delta A_1(\gamma) > \Delta A_1(\beta)$

Proposition 8 implies that Set 1 is the relevant one. Also $q(\gamma) = 1$ from Proposition 6.

Set 1 is:

$$\Delta A_1(\gamma)\Big[q(\beta)\Big(1 - 2P(\beta)\frac{\Delta A_1(\beta)}{\Delta A_1(\gamma)}\Big) - q(\gamma)(1 - 2P(\beta))\Big] \geq 0,$$
$$\Delta A_1(\beta)\Big[q(\gamma)\Big(1 - 2P(\gamma)\frac{\Delta A_1(\gamma)}{\Delta A_1(\beta)}\Big) - q(\beta)(1 - 2P(\gamma))\Big] \leq 0.$$

Since $0 > \Delta A_1(\gamma) > \Delta A_1(\beta)$, we can simplify the above into:

$$q(\beta)\Big(1 - 2P(\beta)\frac{\Delta A_1(\beta)}{\Delta A_1(\gamma)}\Big) - (1 - 2P(\beta)) \leq 0, \quad \Big(1 - 2P(\gamma)\frac{\Delta A_1(\gamma)}{\Delta A_1(\beta)}\Big) - q(\beta)(1 - 2P(\gamma)) \geq 0$$

[Case 1: $P(\gamma) > \frac{1}{2} > P(\beta)$] Then the above is simplified into:

$$q(\beta) \underbrace{\frac{1 - 2P(\beta)\frac{\Delta A_1(\beta)}{\Delta A_1(\gamma)}}{1 - 2P(\beta)}}_{(a)} \leq 1, \quad \underbrace{\frac{1 - 2P(\gamma)\frac{\Delta A_1(\gamma)}{\Delta A_1(\beta)}}{1 - 2P(\gamma)}}_{(b)} \leq q(\beta)$$

Clearly the first constraint is irrelevant as the PM wants to minimize $q(\beta)$.

If $(b) \in (0,1)$, then the optimal solution is $< q(\gamma) = 1, q(\beta) = \frac{1-2P(\gamma)\frac{\Delta A_1(\gamma)}{\Delta A_1(\beta)}}{1-2P(\gamma)} >$. If $(b) < 0$, then the second constraint is also irrelevant; thus, the optimal solution is $< q(\gamma) = 1, q(\beta) = 0 >$. In summary, the optimal solution is:

$$\text{For } P(\gamma) > 1/2 > P(\beta),\ \Big\langle q(\gamma) = 1, q(\beta) = \max\Big(0, \frac{1 - 2P(\gamma)\frac{\Delta A_1(\gamma)}{\Delta A_1(\beta)}}{1 - 2P(\gamma)}\Big)\Big\rangle.$$

[Case 2: $P(\gamma) < \frac{1}{2} < P(\beta)$] The incentive compatibility constraints are:

$$q(\beta) \underbrace{\frac{1 - 2P(\beta)\frac{\Delta A_1(\beta)}{\Delta A_1(\gamma)}}{1 - 2P(\beta)}}_{(a)>1} \geq 1, \quad \underbrace{\frac{1 - 2P(\gamma)\frac{\Delta A_1(\gamma)}{\Delta A_1(\beta)}}{1 - 2P(\gamma)}}_{(b)>1} \geq q(\beta)$$

Note that $(a) > 1$ and $(b) > 1$. Thus, the second constraint is irrelevant, and the result follows.

A.2.5 Case vi: $\Delta A_1(\gamma) > 0 > \Delta A_1(\beta)$

Proposition 8 implies that Set 1 is the relevant one. Also $q(\gamma) = 1$ from Proposition 6. Since $\Delta A_1(\gamma) > 0 > \Delta A_1(\beta)$, we can simplify these into:

$$q(\beta)\Big(1 - 2P(\beta)\frac{\Delta A_1(\beta)}{\Delta A_1(\gamma)}\Big) - (1 - 2P(\beta)) \geq 0, \quad \Big(1 - 2P(\gamma)\frac{\Delta A_1(\gamma)}{\Delta A_1(\beta)}\Big) - q(\beta)(1 - 2P(\gamma)) \geq 0$$

[Case 1: $P(\gamma) > \frac{1}{2} > P(\beta)$] Then the above is simplified into:

$$q(\beta) \underbrace{\frac{1 - 2P(\beta)\frac{\Delta A_1(\beta)}{\Delta A_1(\gamma)}}{1 - 2P(\beta)}}_{(a)} \geq 1, \quad \underbrace{\frac{1 - 2P(\gamma)\frac{\Delta A_1(\gamma)}{\Delta A_1(\beta)}}{1 - 2P(\gamma)}}_{(b)} \leq q(\beta)$$

Note that $(a) > 1$ and $(b) < 0$, so that the second constraint is irrelevant, and the result follows from the first constraint.

[Case 2: $P(\gamma) < \frac{1}{2} < P(\beta)$**]** The incentive compatibility constraints are:

$$q(\beta)\underbrace{\frac{1-2P(\beta)\frac{\Delta A_1(\beta)}{\Delta A_1(\gamma)}}{1-2P(\beta)}}_{(a)<0} \leq 1, \quad \underbrace{\frac{1-2P(\gamma)\frac{\Delta A_1(\gamma)}{\Delta A_1(\beta)}}{1-2P(\gamma)}}_{(b)>1} \geq q(\beta)$$

Note that $(a) < 0$ and $(b) > 1$. Thus, the first constraint is irrelevant, and the result follows.

A.3 Model without short selling

A.3.1 Incentive compatibility constraints

The 1st set: Buy if and only if the signal is γ.

Making the right-hand side of (IC'_{11}) and the left-hand side of (IC'_{12}) zero, the two incentive compatibility constraints without the possibility of short sale become:

$$q(\gamma)\Delta A_1(\gamma) \geq q(\beta)\Delta A_1(\beta) \tag{14}$$

$$P(\gamma)q(\gamma)\Delta A_1(\gamma) \geq (q(\gamma) - P(\beta)q(\beta))\Delta A_1(\beta) \tag{15}$$

The 2nd set: Buy if and only if the signal is β

Similar to the 1st set, we derive Set 2 without the possibility of short sale:

$$q(\beta)\Delta A_1(\beta) \geq q(\gamma)\Delta A_1(\gamma) \tag{16}$$

$$P(\beta)q(\beta)\Delta A_1(\beta) \geq (q(\beta) - P(\gamma)q(\gamma))\Delta A_1(\gamma) \tag{17}$$

Remark: Note that plugging $\tilde{q} := q(\gamma) = q(\beta)$ into the four constraints, we can prove Proposition 4 the same way. Also all four constraints are of form $Cq(\gamma) \gtreqless q(\beta)$; thus, the proof for Proposition 6 can be done the same way in the current environment too. Plugging $\tilde{q} := q(\gamma) = q(\beta)$ into the four constraints makes it possible to show Proposition 9 the same way too. Finally, inequalities (9) are written as follows in the current environment:

$$q(\gamma)\Delta A_1(\gamma) - \mathbb{E}(\Delta A_1) \geq 0 \geq q(\gamma)\Delta A_1(\beta) - \mathbb{E}(\Delta A_1)$$

Thus, the non-emptiness of the above set implies $\Delta A_1(\gamma) \geq \Delta A_1(\beta)$. Thus, Proposition 8 can be proven the same way in the current environment.

In summary, the incentive-constrained optimal policy satisfies $1 = q(\gamma) \geq q(\beta)$, and Set 1 (Set 2) is the relevant one if and only if $\Delta A_1(\gamma) \geq \Delta A_1(\beta)$ ($\Delta A_1(\gamma) \leq \Delta A_1(\beta)$).

A.3.2 Further simplification of the two sets of incentive compatibility constraints

With $q(\gamma) = 1$, we can rewrite the second constraint of Set 1 as:

$$\begin{aligned} & P(\gamma)\Delta A_1(\gamma) \geq \Delta A_1(\beta) - q(\beta)P(\beta)\Delta A_1(\gamma) \\ \Leftrightarrow\ & q(\beta)P(\beta)\Delta A_1(\beta) \geq (\Delta A_1(\beta) - P(\gamma)\Delta A_1(\gamma)) = (\Delta A_1(\beta) - (1 - P(\beta))\Delta A_1(\gamma)) \\ & q(\beta)\Delta A_1(\beta) \geq \Big(\frac{\Delta A_1(\beta) - \Delta A_1(\gamma)}{P(\beta)} + \Delta A_1(\gamma)\Big) \end{aligned}$$

Thus Set 1 is combined into:

$$\Delta A_1(\gamma) \geq \Delta A_1(\beta)q(\beta) \geq \Big[\frac{\Delta A_1(\beta) - \Delta A_1(\gamma)}{P(\gamma)} + \Delta A_1(\gamma)\Big], \tag{18}$$

and Set 2 is similarly combined into

$$\Delta A_1(\beta)q(\beta) \geq \Delta A_1(\gamma) \geq \Big[\frac{\Delta A_1(\gamma) - \Delta A_1(\beta)}{P(\beta)} + \Delta A_1(\beta)\Big]q(\beta). \tag{19}$$

A.3.3 $\Delta A_1(\gamma) > \Delta A_1(\beta) > 0$

We consider Set 1, inequalities (18).

$$\Delta A_1(\gamma) \geq \Delta A_1(\beta)q(\beta) \geq \Big[\frac{\Delta A_1(\beta) - \Delta A_1(\gamma)}{P(\gamma)} + \Delta A_1(\gamma)\Big],$$

Since the policymaker wants to minimize $q(\beta)$, the only constraint that might bind is the second one. Note that the bracket term could be positive or negative depending on the sign of $\Delta A_1(\beta) - P(\beta)\Delta A_1(\gamma)$ since $\frac{\Delta A_1(\beta) - \Delta A_1(\gamma)}{P(\gamma)} + \Delta A_1(\gamma) = \frac{1}{P(\gamma)}(\Delta A_1(\beta) - (1 - P(\gamma))\Delta A_1(\gamma)) = \frac{1}{P(\gamma)}(\Delta A_1(\beta) - P(\beta)\Delta A_1(\gamma))$.

If $\frac{1}{P(\gamma)}(\Delta A_1(\beta) - P(\beta)\Delta A_1(\gamma)) < 1$, the constraint does not bind, and the optimal solution is $< q(\gamma) = 1, q(\beta) = 0 >$.

On the other hand if $\frac{1}{P(\gamma)}(\Delta A_1(\beta) - P(\beta)\Delta A_1(\gamma)) > 1$, the constraint is binding; thus, the optimal solution is $\Big\langle q(\gamma) = 1, q(\beta) = \frac{1}{P(\gamma)}\Big(1 - P(\beta)\frac{\Delta A_1(\gamma)}{\Delta A_1(\beta)}\Big)\Big\rangle$.

In summary, the optimal policy is

$$\Big\langle q(\gamma) = 1, q(\beta) = \max\Big(0, \frac{1}{P(\gamma)}\Big(1 - P(\beta)\frac{\Delta A_1(\gamma)}{\Delta A_1(\beta)}\Big)\Big)\Big\rangle.$$

A.3.4 $\Delta A_1(\beta) > \Delta A_1(\gamma) > 0$

We consider Set 2:

$$\Delta A_1(\beta)q(\beta) \geq \Delta A_1(\gamma) \geq \Big[\frac{\Delta A_1(\gamma) - \Delta A_1(\beta)}{P(\beta)} + \Delta A_1(\beta)\Big]q(\beta).$$

Since the policymaker wants to minimize $q(\beta)$, the only the first constraint binds. Thus, the solution is:

$$\Big\langle q(\gamma) = 1, q(\beta) = \frac{\Delta A_1(\gamma)}{\Delta A_1(\beta)}\Big\rangle.$$

A.3.5 $\Delta A_1(\beta) > 0 > \Delta A_1(\gamma)$

We consider Set 2:

$$\Delta A_1(\beta)q(\beta) \geq \Delta A_1(\gamma) \geq \Big[\frac{\Delta A_1(\gamma) - \Delta A_1(\beta)}{P(\beta)} + \Delta A_1(\beta)\Big]q(\beta).$$

The only constraint that might bind is the second one, which is re-written as $1 \leq \Big[\frac{1-\frac{\Delta A_1(\beta)}{\Delta A_1(\gamma)}}{P(\beta)} + \frac{\Delta A_1(\beta)}{\Delta A_1(\gamma)}\Big]q(\beta)$. Note that the bracket term is simplified as $\frac{1}{P(\beta)}\Big[1 - \frac{\Delta A_1(\beta)}{\Delta A_1(\gamma)} + P(\beta)\frac{\Delta A_1(\beta)}{\Delta A_1(\gamma)}\Big] = \frac{1-P(\gamma)\frac{\Delta A_1(\beta)}{\Delta A_1(\gamma)}}{P(\beta)}$, which is larger than 1 since $P(\beta) < 1$ and $1 - P(\gamma)\frac{\Delta A_1(\beta)}{\Delta A_1(\gamma)} > 1$. Thus, the solution is:

$$\Big\langle q(\gamma) = 1, q(\beta) = \frac{P(\beta)}{1 - P(\gamma)\frac{\Delta A_1(\beta)}{\Delta A_1(\gamma)}}\Big\rangle.$$

A.3.6 $0 > \Delta A_1(\beta) > \Delta A_1(\gamma)$

We consider Set 2:

$$[-\Delta A_1(\beta)]q(\beta) \leq [-\Delta A_1(\gamma)] \leq \Big[\frac{-\Delta A_1(\gamma) + \Delta A_1(\beta)}{P(\beta)} - \Delta A_1(\beta)\Big]q(\beta).$$

Since the policymaker wants to minimize $q(\beta)$, the second inequality binds, which is re-written as:

$$1 \leq \Big[\frac{1 - \frac{\Delta A_1(\beta)}{\Delta A_1(\gamma)}}{P(\beta)} + \frac{\Delta A_1(\beta)}{\Delta A_1(\gamma)}\Big]q(\beta).$$

Note that the bracket term is simplified as $\frac{1}{P(\beta)}\Big[1-\frac{\Delta A_1(\beta)}{\Delta A_1(\gamma)}+P(\beta)\frac{\Delta A_1(\beta)}{\Delta A_1(\gamma)}\Big]=\frac{1-P(\gamma)\frac{\Delta A_1(\beta)}{\Delta A_1(\gamma)}}{P(\beta)}$, which is larger than 1 since $\Big(1-P(\gamma)\frac{\Delta A_1(\beta)}{\Delta A_1(\gamma)}\Big)>1-P(\gamma)=P(\beta)$. Thus solution is:

$$\Big\langle q(\gamma)=1, q(\beta)=\frac{P(\beta)}{1-P(\gamma)\frac{\Delta A_1(\beta)}{\Delta A_1(\gamma)}}\Big\rangle.$$

A.3.7 $0>\Delta A_1(\gamma)>\Delta A_1(\beta)$

We consider Set 1:

$$[-\Delta A_1(\gamma)]\leq[-\Delta A_1(\beta)]q(\beta)\leq\underbrace{\Big[\frac{-\Delta A_1(\beta)+\Delta A_1(\gamma)}{P(\gamma)}-\Delta A_1(\gamma)\Big]}_{(+)}.$$

Since the policymaker wants to minimize $q(\beta)$, the first inequality binds. Thus, the solution is:

$$\Big\langle q(\gamma)=1, q(\beta)=\Big(\frac{-\Delta A(\gamma)}{-\Delta A_1(\beta)}\Big)\Big\rangle.$$

A.3.8 $\Delta A_1(\gamma)>0>\Delta A_1(\beta)$

We consider Set 1:

$$\Delta A_1(\gamma)\geq\Delta A_1(\beta)q(\beta)\geq\Big[\frac{\Delta A_1(\beta)-\Delta A_1(\gamma)}{P(\gamma)}+\Delta A_1(\gamma)\Big].$$

To minimize $q(\beta)$, the only constraint that might bind is the second constraint.

Dividing both sides by $\Delta A_1(\beta)$, we derive $q(\beta)\leq\Big[\frac{1-\frac{\Delta A_1(\gamma)}{\Delta A_1(\beta)}}{P(\gamma)}+\frac{\Delta A_1(\gamma)}{\Delta A_1(\beta)}\Big]$ since $\Delta A_1(\beta)$ is negative. Then $q(\beta)=0$ satisfies the constraint. Thus, the solution is:

$$< q(\gamma)=1, q(\beta)=0 > .$$

A.4 Derivation for case of fixed A_0, no short-selling, condition (10)

The first set of incentive compatibility constraints (13) is equivalent to the following under condition (10):

$$q(\gamma)\geq\frac{-\mathbb{E}\,V(ne|\gamma)}{\mathbb{E}\,V(e|\gamma)-\mathbb{E}\,V(ne|\gamma)}\quad\text{and}\quad q(\gamma)\leq\frac{-\mathbb{E}\,V(ne|\beta)}{\mathbb{E}\,V(e|\beta)-\mathbb{E}\,V(ne|\beta)}.$$

Moreover we get the following with condition (10):

$$\frac{-\mathbb{E}\,V(ne|\gamma)}{\mathbb{E}\,V(e|\gamma)-\mathbb{E}\,V(ne|\gamma)} < \frac{-\mathbb{E}\,V(ne|\beta)}{\mathbb{E}\,V(e|\beta)-\mathbb{E}\,V(ne|\beta)}.$$

Thus, the two constraints become

$$\frac{-\mathbb{E}\,V(ne|\gamma)}{\mathbb{E}\,V(e|\gamma)-\mathbb{E}\,V(ne|\gamma)} \leq q(\gamma) \leq \frac{-\mathbb{E}\,V(ne|\beta)}{\mathbb{E}\,V(e|\beta)-\mathbb{E}\,V(ne|\beta)}.$$

The policy maker wants to increase $q(\gamma)$ as long as the two incentive compatibility constraints are satisfied. Thus, we conclude:

$$q(\gamma) = \frac{-\mathbb{E}\,V(ne|\beta)}{\mathbb{E}\,V(e|\beta)-\mathbb{E}\,V(ne|\beta)} = \frac{1}{\frac{\mathbb{E}\,V(e|\beta)}{-\mathbb{E}\,V(ne|\beta)}+1}.$$

Note that this value is between 0 and 1 under condition 10.

A.5 Short selling or buying is superior to *not buying*

Consider the case of $\Delta A_1(\gamma) > \Delta A_1(\beta)$. $\mathcal{II}(\gamma)$'s payoff when he buys and $\mathcal{II}(\beta)$'s payoff when he short sells are, respectively:

$$q(\gamma)\Delta A_1(\gamma) - (P(\gamma)q(\gamma)\Delta A(\gamma) + P(\beta)q(\beta)\Delta A(\beta)) = P(\beta)[q(\gamma)\Delta A_1(\gamma) - q(\beta)\Delta A_1(\beta)], \text{ and}$$
$$-q(\beta)\Delta A_1(\beta) + (P(\gamma)q(\gamma)\Delta A(\gamma) + P(\beta)q(\beta)\Delta A(\beta)) = P(\gamma)[q(\gamma)\Delta A_1(\gamma) - q(\beta)\Delta A_1(\beta)]$$

As shown in Lemma 5, $q(\gamma) \geq q(\beta)$ must be the case. (Note that the proof for Lemma 5 depends only on the PM's welfare function.)

For case (i) in which $\Delta A_1(\gamma) > \Delta A_1(\beta) > 0$, both of the above payoffs are positive since $q(\gamma) \geq q(\beta)$. The same holds for case (vi) in which $\Delta A_1(\gamma) > 0 > \Delta A_1(\beta)$. For case (v) in which $0 > \Delta A_1(\gamma) > \Delta A_1(\beta)$, suppose $P(\gamma) > P(\beta)$. Plugging the optimal $q(\beta)$ and $q(\gamma) = 1$ into $q(\gamma)\Delta A_1(\gamma) - q(\beta)\Delta A_1(\beta)$, we derive:

$$\Delta A_1(\gamma) - \frac{1-2P(\gamma)\frac{\Delta A_1(\gamma)}{\Delta A_1(\beta)}}{1-2P(\gamma)}\Delta A_1(\beta) = \frac{\Delta A_1(\gamma) - \Delta A_1(\beta)}{1-2P(\gamma)} > 0.$$

On the other hand, suppose $P(\gamma) < P(\beta)$. Plugging the optimal $q(\beta)$ and $q(\gamma) = 1$ into $q(\gamma)\Delta A_1(\gamma) - q(\beta)\Delta A_1(\beta)$, we derive:

$$\Delta A_1(\gamma) - \frac{1-2P(\beta)}{1-2P(\beta)\frac{\Delta A_1(\beta)}{\Delta A_1(\gamma)}}\Delta A_1(\beta) = \frac{\Delta A_1(\gamma) - \Delta A_1(\beta)}{1-2P(\beta)\frac{\Delta A_1(\beta)}{\Delta A_1(\gamma)}} > 0.$$

Thus, we have shown that the two payoffs are non-negative when $\Delta A_1(\gamma) > \Delta A_1(\beta)$.

Similarly, consider the case of $\Delta A_1(\gamma) < \Delta A_1(\beta)$. $\mathcal{II}(\gamma)$'s payoff when he short sells and $\mathcal{II}(\beta)$'s payoff when he buys are, respectively:

$$-q(\gamma)\Delta A_1(\gamma) + (P(\gamma)q(\gamma)\Delta A(\gamma) + P(\beta)q(\beta)\Delta A(\beta)) = P(\gamma)[q(\beta)\Delta A_1(\beta) - q(\gamma)\Delta A_1(\gamma)], \text{ and}$$
$$q(\beta)\Delta A_1(\beta) - (P(\gamma)q(\gamma)\Delta A(\gamma) + P(\beta)q(\beta)\Delta A(\beta)) = P(\beta)[q(\beta)\Delta A_1(\beta) - q(\gamma)\Delta A_1(\gamma)]$$

For case (ii) in which $\Delta A_1(\beta) > \Delta A_1(\gamma) > 0$, suppose $P(\gamma) > P(\beta)$. Plugging the optimal $q(\beta)$ and $q(\gamma) = 1$ into $[q(\beta)\Delta A_1(\beta) - q(\gamma)\Delta A_1(\gamma)]$, we derive

$$\frac{1 - 2P(\gamma)\frac{\Delta A_1(\gamma)}{\Delta A_1(\beta)}}{1 - 2P(\gamma)}\Delta A_1(\beta) - \Delta A_1(\gamma) = \frac{\Delta A_1(\beta) - \Delta A_1(\gamma)}{1 - 2P(\gamma)} > 0.$$

On the other hand, suppose $P(\gamma) < P(\beta)$. Plugging the optimal $q(\beta)$ and $q(\gamma) = 1$ into $[q(\beta)\Delta A_1(\beta) - q(\gamma)\Delta A_1(\gamma)]$, we derive

$$\frac{1 - 2P(\beta)}{1 - 2P(\beta)\frac{\Delta A_1(\beta)}{\Delta A_1(\gamma)}}\Delta A_1(\beta) - \Delta A_1(\gamma) = \frac{\Delta A_1(\beta) - \Delta A_1(\gamma)}{1 - 2P(\beta)\frac{\Delta A_1(\beta)}{\Delta A_1(\gamma)}} > 0.$$

For case (iii) in which $\Delta A_1(\beta) > 0 > \Delta A_1(\gamma)$, the two payoffs are trivially non-negative. The same holds for case (iv) in which $0 > \Delta A_1(\beta) > \Delta A_1(\gamma)$.

Thus we have shown that the payoffs are also non-negative when $\Delta A_1(\gamma) < \Delta A_1(\beta)$.