Formal Requirements on Costly Information

Saba Devdariani*

Abstract

There is empirical evidence that government advisory committees generate biased policy decisions. The literature has primarily focused on assessing the influence of procedural restrictions imposed by government agencies on these advisory committees, assuming that their preferences are biased. Little theoretical research has been done to understand the inner workings of these committees and the origins of bias in their decision-making. In our study, we highlight a flaw in the operating procedures of advisory committees, specifically the allowance for the proposer to determine the amount of public information gathered. This flaw leads to biased decisions, even when the decision-maker is unbiased. We explore the optimal mechanism for procedural requirements within the advisory committee and show how it improves the final policy choice and the overall welfare. We analyze delegated information acquisition with a biased agent who also has private information about the state of the world. The information acquired is public and its informativeness increases with a costly effort. When the agent decides the effort level, the low type abstains from acquiring any public information, whereas the high type acquires just enough public information to separate itself from the low type. In the optimal mechanism with formal requirements, the principal incentivizes the low-type agent to truthfully reveal her private information by requiring a relatively low amount of costly effort, while the high private report has to be followed by the maximum effort in public signal.

*The University of Chicago. Devdariani@uchicago.edu

1 Introduction

1.1 Motivation

The U.S. government heavily relies on federal advisory committees, which provide recommendations to various government agencies. The Federal Advisory Committee Act (FACA) limits the authority of these committees in administering advice, which may or may not be utilized by specific government agencies or the executive branch. Although the committees themselves do not make policy decisions, their overall level of influence is substantial. For instance, one such advisory committee, Relative Value Scale Update Committee (the RUC), suggests appropriate values to Medicare, and Medicare's administrators accept these recommendations in over 90% of cases (AoAM (2020); Laugesen, Wada and Chen (2012)). The pricing suggestions from this committee have an impact not only on Medicare's immediate spending but also play a role in shaping pricing across the broader market of physician services, which is valued at $480 billion annually (Clemens and Gottlieb, 2017). This is just one example out of approximately 1,000 Federal advisory committees regulated under FACA.

The primary purpose of advisory committees is for government agencies to gather recommendations from industry representatives who possess crucial knowledge relevant to specific policy choices.Unfortunately, the members of these committees often have personal interests vested in these policy decisions. Consequently, these committees might be prone to issuing biased recommendations that align with industry interests. As a result, the existing literature primarily assumes the presence of such biased preferences, and a significant portion of the research in this field delves into the agency problem that arises between government agencies and these biased committees. There exists an empirical literature examining the impact of administrative procedures on agency performance (Balla, 1998; Kerwin and Furlong, 1992; Potoski, 1999; Yackee and Yackee, 2010).

In this study, we advance the research on federal advisory committees by formulating a formal theoretical model that shows the sources of bias in policy decisions, even when the final policy determination is made by an unbiased committee. Additionally, we demonstrate how the committee itself can impose procedural requirements, rather than having them imposed upon them, to enhance the fairness of policy choices and promote overall welfare. Our approach suggests that the bias observed in policy decisions emanates from another agency problem within the committee's working procedures, which cannot be resolved through standard "auditing" or procedural requirements commonly employed in the literature on bureaucratic oversight.[1] We illustrate of how the optimal mechanism based on

[1]We do not model the interaction between advisory committees and government agencies. Instead, we endogenize bias in elected policies by modeling the relationship between the unbiased committee (Principal)

formal requirements might work.

We construct a model with an unbiased principal (the committee) who selects the optimal policy choice based on the unobserved binary state of the world. [2]The principal relies on a proposal comprising private (soft) and public (hard) information from a biased agent (the proposer). The agent's preferences are biased toward selecting the highest possible policy. Private information incurs no cost for the agent and is unverifiable for the principal, while acquiring public information requires costly effort from the agent. This public information is publicly observable but cannot be proven false. We analyze the equilibria of two different models: (1) when the agent can freely choose the amount of costly public information to support their proposal, and (2) when the principal imposes formal requirements on the amount of public information, conditional on the private report from the agent. Our problem combines elements from the literature on delegated information acquisition and the persuasion literature, as the agent possesses private information and biased preferences. The key idea is that when the principal lacks control over the amount of public information required, the biased agent can manipulate it in their favor to achieve higher policy outcomes.

To better understand our motivation, we apply our model to the context of Medicare pricing for medical services. The committee of physicians, known as the RVS Update Committee (RUC), makes final pricing decisions based on proposals from a group of specialists or individual doctors.[3] We assume that the committee aims to establish fair prices for medical services. In practice, proposers provide subjective opinions based on their expertise (soft information) and survey results (hard information) to support their price evaluations. However, the fact that proposers often perform the medical services under consideration biases their preferences towards higher prices. In reality, proposers are free to choose the number of people surveyed, resulting in variations across proposals. Therefore, proposers could manipulate the number of people surveyed to achieve higher prices.

Our findings support this intuition. When agents are free to choose the amount of public information, they do not reveal their private information when the public signal is relatively inexpensive. In the best equilibrium for the principal, the agent always acquires the maximum public information (without revealing their private signal), and the principal makes a decision solely based on this information. However, when the cost of the public signal is sufficiently high, separation becomes possible. In equilibrium, an agent with a low private signal acquires no public information, and their proposal consists solely of their

and the biased member of the committee (Agent).

[2]As previously discussed, advisory committees provide policy recommendations that almost always translate into actual policy choices. Since we do not model government agencies that make the final policy choices based on committee recommendations, we treat these recommendations as actual final policy choices.

[3]Medicare utilizes a physician payment system based on the resource-based relative value scale (RBRVS).

private report. Since the agent with a low private signal expects the public signal to align with the lower policy choice, they choose not to acquire any public information to avoid an undesirable outcome. The preferences of an agent with a high private signal coincide with those of the principal. In equilibrium, such an agent acquires a small amount of public signal, just enough to differentiate themselves from the agent with a low signal and make their private report believable.

In contrast, when the principal can impose formal requirements on the amount of public signal, the public signal serves two purposes: (1) increasing the precision of the policy choice, and (2) extracting the private signal from the agent, provided the principal conditions the requirements on the "soft information" reported by the proposer. Our analysis reveals that if the public information is too inexpensive, it fails to serve the second purpose. However, for sufficiently high costs, the optimal mechanism necessitates maximum evidence (in terms of public signal) to support a proposal with a high private report. As the low private report contradicts the agent's preferences, such a proposal must be accompanied by less public evidence. This mechanism incentivizes the agent to reveal their low private signal by alleviating some of the burden of acquiring costly public signal.

Welfare analysis demonstrates the benefits of formal requirements. When the costs are high enough, separation (truthful revelation of the agent's private information) is possible in both models. However, the motivation and mechanism behind separation differ depending on who controls the amount of public signal. When the decision lies with the agent, an agent with a high private signal acquires just enough public signal to differentiate themselves from the agent with a low signal.[4] As the cost of the public signal increases, it becomes easier for the high type to make their private report believable, resulting in even less acquisition of public signal and decreased welfare for the principal. Conversely, when the principal imposes formal requirements on the public signal, in a separating equilibrium, the costly public signal serves as a mechanism to encourage the low type to reveal their private signal by reducing the burden of public proof. With costly public signal, the formal requirement becomes a more effective tool for the principal, aiding separation and allowing for less compromise on the public signal from the low type. Overall, when the principal imposes formal requirements, their expected welfare in equilibrium increases with the cost of information.

Another interesting finding is that agents sometimes separate when the principal would prefer to disregard their private reports in favor of a more reliable public signal. If the private signal holds limited value and the cost of the public signal is moderate, in the absence of formal requirements, the agent would truthfully reveal their type and exert minimal effort in acquiring public signal. Meanwhile, under the same parameters, the principal does not

[4] We refer to the agent's private signal as their type.

find separation worth sacrificing some public signal. However, when the principal imposes formal requirements, they prefer to require maximum public signal from everyone and base the policy decision solely on the maximum public information.

In summary, there is reason to believe that that government advisory committees generate biased policy decisions. While existing literature has primarily focused on assessing the influence of various procedural restrictions imposed by government agencies on these advisory committees (such as transparency, feedback on recommendations, etc.), assuming the presence of biased preferences, there has been limited theoretical research exploring the inner workings of these committees and the origins of bias in their decisions. Our paper highlights a notable flaw in the operating procedures of advisory committees, specifically the allowance for proposers to choose the amount of public signal, resulting in biased decisions even with unbiased principal. We explore the optimal mechanism for procedural requirements within the advisory committee and show how it improves the final policy choice and the overall welfare.

1.2 Broader Application of the Model

The key features of our model are: (1) biased agent with private information, and the (2) existence of costly verifiable public information. Our model is applicable to large class of government advisory committees (not just RUC) since majority of them fit criteria of our model. For instance, the FDA maintains over 30 standing advisory committees (ACs) responsible for evaluating products being reviewed by its Center for Drug Evaluation and Research. The structure and operational procedures of these committees closely resemble those of the RUC. Each advisory committee consists of 10 to 20 members who specialize in specific disease areas or technological fields such as oncology, anti-infectives, reproductive health, and more. Given their expertise in these domains, these experts often have affiliations with pharmaceutical companies, which can introduce bias into their preferences.[5] Members are obligated to report any conflict of interests but they are often waived. Typically, the rationale for disregarding conflicts of interest is the significance of the committee member's expertise, which is considered private information, in comparison to the extent of the financial connection. In theory, the committees could obligate their member to provide additional research (costly verifiable information) in order to substantiate their recommendations concerning the drugs under evaluation. This proposed setup aligns perfectly with our model specifications and implies that procedural requirements on this verifiable costly information could enhance the quality of recommendations put forth by these advisory committees. The

[5] Camara and Kyle (2017) investigate how FDA advisors with financial ties to the pharmaceutical industry vote differently.

same reasoning applies to the U.S. International Trade Commission (ITC), an autonomous, nonpartisan, quasi-judicial federal agency entrusted with conducting diverse trade-related analyses for both the executive and legislative branches.

The setup described in this paper is not uncommon in many principal-agent relationships. When the agent possesses soft private information, it is often feasible to request costly verifiable information (such as additional market research or cost-benefit analysis) as well. Consequently, while the primary application of our model pertains to advisory committees, it can be extended to any principal-agent problem where there exists the potential for costly (for the agent) verifiable public information. For instance, this paper also presents alternative explanations for agency-specific statutory requirements frequently employed by Congress. In the broader context, the conventional study of administrative law perceives administrative procedures as mechanisms to ensure fairness and legitimacy in the decisions made by administrators. Its foundation lies in constitutional and common law principles like non-delegation, separation of powers, and due process, among others. However, this perspective doesn't account for why legislative measures frequently outline administrative procedures that surpass the needs for ensuring alignment with these principles, often being tailored to specific agencies (McCubbins, Noll and Weingast, 1987).

For instance, consider the Environmental Protection Agency (EPA) and the Occupational Safety and Health Administration (OSHA) – both entities often regulate the same pollutants. Yet, their procedural requisites differ substantially, especially in terms of the methodologies employed to assess regulations or the essential research documents demanded (verifiable costly information). This example encompasses all the key features of our model: these agencies are often believed to harbor biased preferences due to their affiliations with industries, they possess expert knowledge (private information) and are procedurally obliged to provide particular verifiable information. The findings of our paper offer explanations for the specificity of the statutory regulations that Congress frequently imposes on these agencies, tailored to their circumstances.

1.3 Related Literature

Our paper contributes to the extensive literature on agency problems in political science, particularly in the realm of bureaucratic oversight. The literature classifies bureaucratic control into two primary categories (Harris, 1964): ex-post oversight, involving direct auditing of the bureaucrat's actions (Weingast and Moran, 1983), and indirect control based on a fire alarm system facilitated by interest groups (McCubbins, Noll and Weingast, 1987); and ex-ante prevention utilizing various procedural requirements (McCubbins, Noll and Weingast, 1987, 1989). This paper focuses on the latter category. Proponents of the positive theory of administrative procedure have demonstrated the benefits of employing procedural requirements for legislative oversight. Conversely, supporters of the "ossification thesis" (Mashaw, 1990; McGarity, 1992, 1996; Pierce Jr, 1995; Seidenfeld, 1997, 2009; Verkuil, 1995) argue that procedural constraints hinder the efficient operation of many agencies. Most research in this area examines the interaction between elected officials (such as the president or Congress) and government agencies, assuming biased preferences of the agencies. In contrast, our focus lies in exploring the decision-making process of advisory committees to address the agency problem within, using verifiable costly information as a partial resolution.

Given that the principal in our model employs costly verifiable public signals to scrutinize the agent's soft/private reports, our paper is also connected to the literature on costly verification (Townsend, 1979; Ben-Porath, Dekel and Lipman, 2014; Mylovanov and Zapechelnyuk, 2017), particularly the work of Halac and Yared (2020), who examine the general delegation framework with costly but feasible verification. The key distinction is that "auditing" in our model is a continuous decision, as the principal must choose the effort level $e \in [0, 1]$, and the outcome/precision of the audit is imperfect, contingent upon this effort level. Additionally, in our case, the "cost of the audit" is entirely borne by the agent, who possesses state-independent preferences.

The main model in this study depicts a scenario where the principal controls the agent's effort level in acquiring the public signal but lacks the ability to commit to an arbitrary decision rule. This model can be categorized as a mechanism design problem with limited commitment. The initial motivation for the paper stems from the persuasion literature concerning a biased and informed agent. Kamenica and Gentzkow (2011) establish the necessary and sufficient conditions for the existence of a signal that strictly benefits the sender. In their example, under specific conditions, an agent can construct a truthful signal that yields a favorable outcome. Similarly, in the absence of formal requirements from the principal, the proposer, who consistently favors higher Medicare prices, may be able to construct a signal beneficial to their cause (though now constrained by survey evidence).

The findings of Ekmekci and Lauermann (2020) are more relevant to our example, focusing on biased election organizations. According to their model, if voters are uncertain about the correct state but unaware of the electorate size, the organizer can ensure a favorable outcome with high probability. The authors demonstrate that when the number of participants varies across states in an exogenous manner, biased equilibrium can be sustained in large elections. In their model, the organizer possesses prior knowledge of the state. This assumption aligns with our case, assuming that the proposer has a good sense of fair prices. The implications of their paper suggest that even without assuming automatic satisfaction of voters' incentive compatibility, the proposer can manipulate the number of people surveyed and ensure that the survey's outcome supports their claim of high prices with high probability. Consequently, the prices of medical services will be biased upwards if the committee bases its decision on the survey results.

As mentioned earlier, Chan and Dickstein (2017) provide empirical support for this hypothesis. The authors also examine how price bias increases with the committee's affiliation. The difference in our case is that we assume no affiliation since the proposer is biased, whereas the committee always seeks fair prices. As briefly discussed in the last section, introducing partial bias for the committee could be a possible extension of our model.

The findings in the persuasion literature suggest that the current mechanism employed by the RUC, which does not regulate the number of people surveyed, could result in higher prices. In this paper, we demonstrate how the RUC can utilize formal requirements for the amount of hard information gathered to ensure more equitable pricing of medical services. A similar question has been explored by Henry and Ottaviani (2019). The authors adopt a game-theoretic approach to compare outcomes of three different setups, relaxing the assumption of full commitment in different ways. Their study does not employ a mechanism design approach, and unlike our case, their model does not assume preexisting private information of the agent.

This paper also relates to the literature examining task delegation in both continuous and discrete time structures. However, a significant difference is that we do not incorporate sequential search into our model. The player with authority decides the effort level to acquire public signal (which can be interpreted as the amount of public signal gathered). Furthermore, most of the literature on delegation focuses on the moral hazard problem, which is not relevant in our case, as the effort level exerted is public information, and the agent is unable to falsify or conceal the public signal. The effort level can directly affect the principal's utility through output (Spear and Srivastava, 1987; Sannikov, 2008) or indirectly through the informativeness of the signal (Kashyap and Kovrijnykh, 2016). In our model, we adopt the latter approach by linking the costly effort to the informativeness of the public signal. An important feature of our model is the existence of preexisting private information of the agent, which holds value for the principal.

The remainder of this paper is organized as follows: Section 2 formally establishes the model for the aforementioned problem. Section 3 conducts preliminary analysis of the optimal policy choice. Section 4 presents equilibria for the biased agent, who has the authority to choose their own effort level. This case closely mirrors the real-world procedure of determining prices of medical services by the RUC. Section 5 analyzes the optimal mechanism for the main model, in which the principal formally requires a certain level of effort after each report of soft information from the agent. Section 6 focuses on the welfare comparison between the two models and further explains the mechanism by which formal requirements enhance welfare. Formal proofs are provided in the appendix.

2 The Model

We examine a one-period model involving two players: the principal (referred to as "he") and the agent (referred to as "she"). The principal in our case is the RUC, while the agent is a specialist who puts forward a proposal. To avoid pronoun confusion, we assign gender-specific pronouns. Nature randomly determines a binary state $\omega \in \{0, 1\}$ that dictates the desirable policy choice for the principal.[6] The principal must make a final policy decision $x \in [0, 1]$. In the context of the RUC example, a state of the world can be interpreted as the true difficulty of a specific medical procedure. Specifically, $\omega = 0$ indicates an easy procedure where the committee desires a price of 0, while $\omega = 1$ represents a difficult procedure where the committee aims for a price of 1.

2.1 Information and types

The prior of the state $\omega = 1$ is 0.5. The agent receives a **private signal** s about the state of the world. The precision of this signal is θ, meaning:

$$P(s = 1|\omega = 1) = P(s = 0|\omega = 0) = \theta,$$

where $\theta \in [0.5, 1]$ can be interpreted as the competence level of the agent. Even without further investigation, based on her professional opinion, the proposer has some idea about the difficulty of the procedure. If the agent is completely incompetent, $\theta = \frac{1}{2}$, then she has no prior information and thinks that both states are equally likely. A perfectly competent agent, $\theta = 1$, instead knows the correct state with certainty. The principal knows the competence level of the agent θ but he does not observe the signal s.

The agent can acquire additional **public information** $i \in \{0, 1\}$, but the precision and the cost of this signal are proportional to the effort level. The cost of the effort level $e \in [0, 1]$ is quadratic $c(e) = ce^2$, where $c > 0$. The precision of the public signal depends on the effort level in the following way:

$$P(i = 1|\omega = 1) = P(i = 0|\omega = 0) = m(e) = 0.5(0.5e + 1),$$

[6] We assume that the agent has state-independent preferences.

$m(e)$ is the informativeness/precision of the public signal. If the effort level is 0 ($m(e) = 0.5$), then the signal is random. Since $m(e)$ is increasing in e, the probability of getting the correct public signal increases with effort. The public information acquired by the agent in the RUC example is the surveys filled out by different doctors and the effort is the relative number of filled surveys. Observe that for $e = 1$, we have $m(e = 1) = 0.75 < 1$, meaning that even if the agent invests maximum effort in the public signal, it will never be certain.[7] This assumption is logical for our example, since no matter how many questionnaires are filled out, their informativeness is always limited (due to the structure of the questionnaires as well as the knowledge of the unknown procedure by the doctors in related fields, and their incentives to invest time and effort in being as precise as possible).

2.2 Utilities

Depending on the true state of the world and the policy choice x, players' utilities are:

$$U_P = -(\omega - x)^2;$$
$$U_A = x - 1.$$

These utilities show that the principal cares about "fairness" and therefore wants to implement correct prices (i.e. $x = \omega$), while the agent is biased toward the highest policy ($x = 1$). Since the proposer's future income directly depends on the price of the medical service under consideration, she wants higher prices regardless of the real difficulty of the procedure.[8]

2.3 Actions and strategies

We characterize strategies for players in our main model where the principal chooses the effort level but cannot make an arbitrary policy decision. For the main model of the paper, we only consider pure strategies, however later we also give numerical example of when semi-separation might be optimal strategy with formal requirements.

- The strategy of the agent is to choose private report based on the realization of her private signal $\tilde{s} : \{0, 1\} \to \{0, 1\}$.

[7] This assumption is needed to rule out a trivial solution when the principal always requires maximum effort in the public signal and finds out the true state with certainty. The nature of the results stays the same if we vary this upper limit.

[8] Preliminary analysis shows that similar results should be achieved with a quadratic utility function for the agent as well. However, the exact calculations and closed-form solutions are easier to achieve with this utility function.

- The principal chooses the effort level for each report from the agent $e : \{0, 1\} \to [0, 1]$.[9]

The principal also makes a final policy decision $x(\tilde{s}, i, e(\tilde{s})) \in [0, 1]$ after observing the public signal and the private report. We consider the model where the principal cannot commit to an arbitrary decision rule for the policy choice. Rather, he has to make an interim rational policy decision based on his posterior belief about the state, conditional on public information, private report, and his own beliefs. In the case of the RUC, the meetings are regulated and transparent to make sure the prices are fair. Since the goal is to match the state, the decision depends on the posterior beliefs after both private and public signals have been observed (given the effort level).

2.4 The sequence

The sequence of the game where the principal imposes formal requirements on the effort level is the following:

0) The principal commits to a mechanism requiring certain effort levels based on private reports of the agent.
1) Nature decides the state ω and private report of the agent s.
2) The agent observes her private signal s and decides what to report to the principal $\tilde{s}(s)$.
3) The principal requires the effort level from the agent, based on her private report $e(\tilde{s})$ as described in (0).
4) The agent invests $e(\tilde{s}(s))$ effort in the public signal and the public signal is realized.
5) The principal observes the public signal and a policy decision is made.
6) Utilities are realized.

It is important to notice that the agent cannot hide public information and has to invest the effort level asked. This assumption is intuitive in the RUC example, since the proposer has to collect the number of surveys required by the RUC and she cannot tamper with their results.

For comparison, we also consider the model where the agent freely chooses the effort level they want to invest in the public signal. This allows us to compare how the costly effort can be used in equilibrium by the biased agent in order to induce higher policy choices.

[9] This is equivalent to principal providing option of two effort levels and the agent choosing one of two effort levels, where each effort is associated with specific beliefs about her private signal.

3 Preliminary Analysis: Policy Decision

First, we calculate the policy choices at each information set and the principal's beliefs, based on our assumption regarding the policy choice. Since the principal's utility function is quadratic, we can deduce that his interim rational policy decision is the posterior belief about the state of the world. By using Bayes' Rule, we can determine policy choices for different effort levels based on each information set.

We need to analyze policy choices for two different cases: (1) when the principal believes the agent chooses different effort levels, revealing her private signals, and (2) when the principal believes the agent always pools on the same effort level, regardless of her private signal. The first case is relevant in separating equilibria, where the agent chooses different effort levels depending on the realization of her private signal, and for off-path beliefs in pooling equilibria.

Claim 1. *If the principal observes public signal k and he believes that the realization of the private signal is j, the optimal policy choice follows the Bayes Rule:*

$$x_{jk}(e) = P(\omega = 1|s = j, i = k)$$

Note that the policy choice depends on the effort level, and higher effort increases the impact of the public signal on the final policy choice. As for the second case:

Claim 2. *If the principal believes the agent always pools on the same effort level, regardless of her private signal, in equilibrium the principal makes a policy decision solely based on the public signal after observing this particular effort level.*

Suppose, by contradiction, that the agent always chooses effort level e but the principal also considers her private report $\tilde{s}$. According to Observation 1, for the same public signal, the principal always makes a lower policy choice after observing a low private signal compared to a high one: $x_{0i}(e) < x_{1i}(e)$ for $i \in 0, 1$. Therefore, the agent strictly prefers to always report a high private signal, and the principal should completely disregard it. With a biased agent, when the agents pool on the same effort level, the private report becomes mere cheap talk.

Corollary 1. *In the pooling equilibrium, after observing low and high public signals and equilibrium effort level e, the principal's optimal policy choices are $x_0^* = 1 - m(e) \quad x_1^* = m(e)$ respectively.*

This corollary directly follows from Claim 2 using Bayes' Rule.

4 Agent Decides Effort

We now consider the case of a biased agent who decides by herself how much effort to exert into the public signal after each realization of her private signal. This arrangement is closer to the reality of how the RUC operates. There is no official requirement for the number of surveys and the proposer decides this amount. The principal cannot commit to the decision rule and chooses his action according to his posterior belief. We select equilibria that satisfy Intuitive Criterion.

4.1 Separating Equilibrium

We aim to determine the best separating equilibrium for the principal that satisfies the Intuitive Criterion. In this equilibrium, we denote e_0^n as the effort level chosen by the agent with low private information, and e_1^n as the effort level chosen by the agent with high private information. To fully characterize the separating equilibrium, we need to specify the values of these two equilibrium effort levels (e_0^n, e_1^n), as well as the off-path beliefs of the principal for all possible effort levels $e \in [0, 1]$.

First, we introduce additional notations that assist in characterizing the equilibria. Let $EU_T^B(e)$ represent the expected utility of an agent with type $T \in \{L, H\}$ (We refer to the agent who receives low private signal $s = 0$ as L type and the agent who receives high private signal $s = 1$ as H type) after choosing the effort level e, given that the principal believes she is a type $B \in \{L, H\}$. For example, $EU_L^L(e)$ is the expected utility of the low-type agent who chooses the effort level e when the principal correctly believes she is the low type, and $EU_L^H(e)$ is the expected utility of the low-type agent after choosing the effort level e when the principal believes she is the high type.

The following points aid in identifying the equilibrium effort level of the low-type agent, e_0^N:

Observation 1. *$EU_L^H(e) \geq EU_L^L(e)$;*

Observation 2. *$EU_L^L(e)$ is decreasing in effort e;*

Observation 3. *For any effort level $e \leq e_0^n$ principal believes the agent is a low type.*

The first observation is that the low-type agent would rather be considered the high type than the low type. This conclusion follows directly from the fact that, all else being equal, the principal always selects a higher policy when he believes the agent is the high type rather than the low type ($x_{10} \geq x_{00}$ and $x_{11} \geq x_{01}$).

The second observation states that when the principal has correct beliefs about the agent's type, the low-type agent prefers to exert as little effort in the public signal as possible. We can observe that the expected utility for the low-type agent, $EU_L^L(e)$, can be decomposed into a benefit of effort and a cost, with the marginal cost being positive and the marginal benefits being independent of the level of effort in the public signal. This is not surprising, as from the agent's perspective, the expected decision made by the principal (based on correct beliefs about the agent's type) is determined by $E(x) = \Pr(\omega = 1|s)$ and does not vary with the precision $m(e)$ of the public signal.

$$EU_L^L(e) = \underbrace{-\Big[P(i=0|s=0)(1-x_{00}) + P(i=1|s=0)(1-x_{01})\Big]}_{B_L^L} - ce^2 = -\theta - ce^2$$

For the third observation, we find that there cannot be an effort level $e' < e_0^n$ at which the principal believes the agent is the high type. In such a case, the low-type agent would have an incentive to deviate to e', be considered the high type (resulting in a higher policy choice for the same realizations of the public signal), and spend less on costly effort.

Based on these three observations, it can be concluded that **in the separating equilibrium, the low-type agent will always exert zero effort ($e_0^n = 0$)**. This result highlights the disadvantage of allowing the agent to choose their own effort level. When the agent has the freedom to choose the level of effort in acquiring a public signal, the low-type agent exerts no effort at all. This finding aligns with the empirical observation of Laugesen, 2017 stating that in the case of the RUC, "the sample sizes of the survey are extraordinarily small."

Moving on, we can make additional observations to identify the equilibrium effort level for the high-type agent, e_1^N, as well as off-path beliefs:

Observation 4. *For any effort level $e \leq e_1^n$, the principal believes the agent is a low type.*

Observation 5. *$EU_L^H(e)$ is decreasing in effort e.*

Similar to Observation 3, since $EU_H^H(e)$ is also decreasing in effort, in separating equilibria, e_1^n should be the lowest effort level at which the principal believes the agent is the high type; otherwise, the high-type agent would have an incentive to deviate.

Observation 5 follows directly from the first-order condition and is intuitive because the low-type agent expects the public signal to agree with her private signal and indicate a lower policy choice. Additionally, a higher effort level e would further decrease the expected policy choice and increase the cost of effort. Therefore, when considered as the high type, the low-type agent prefers the lowest possible effort level.

To ensure that the low-type agent does not mimic the high type, we must have $EU_L^L(e_0^n) \geq EU_L^H(e_1^n)$. If this inequality is strict, a separating equilibrium will not satisfy the Intuitive Criterion. For $e = e_1^n - \epsilon$ with $\epsilon > 0$ small enough, the principal believes the agent is a low type. However, given the most favorable strategy for the principal (considering the agent as the high type), only the high-type agent would want to deviate to this effort level (the expected utility for both agents, when considered as the high type, decreases with effort). With the principal's belief that e is chosen by the high-type agent, the high type will always want to reduce her effort to e. Thus, we determine e_1^n such that the low type is indifferent: $EU_L^L(e_0^n) = EU_L^H(e_1^n)$.

Based on these results, we can formalize the separating equilibria when the agent chooses the effort level in the public signal:

Proposition 1. *When the agent decides effort: a separating equilibrium only exists for high enough costs* $c > \frac{3-6\theta}{-3-4\theta+4\theta^2} \equiv \bar{c}$. *In this equilibrium, the low type exerts no effort* $e_0^n = 0$ *and the high type exerts some intermediate effort level* e_1^n, *where* e_1^n *solves* $EU_L^L(0) = EU_L^H(e_1^n)$. *The off-path beliefs are assuming the agent to be a high type i.f.f.* $e \geq e_1^n$. *This equilibrium satisfied the Intuitive Criterion.*[10]

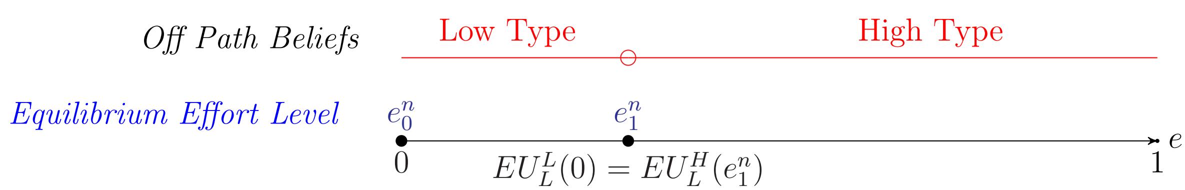

Figure 1: *This Figure shows the separating equilibrium when the agent decides effort, for high enough cost* $c > \bar{c}$.

When the agent chooses the effort level, the existence of a separating equilibrium, where the agent chooses the effort level, depends on the cost being sufficiently high to prevent the low-type agent from deviating and pretending to have a high signal in order to increase the final policy choice (even by exerting maximum effort). Increasing the effort level poses two disadvantages for the low type: the cost of effort and the likelihood of the public signal decreasing the policy decision even further. However, when the cost is very low ($c < \bar{c}$), the first concern becomes insignificant. Moreover, since the public signal is never perfect, even with maximum effort, there are instances where the low type would prefer to be considered a

[10] In the appendix, we show that there is a unique effort level e_1^* for the high type that makes the low type indifferent between reporting either of the private signals. We also check that the high agent does not have an incentive to deviate to any point below $e_1^n < 1$ and be perceived as a low type ($EU_H^H(e_1^n) > max_{e_0 < e_1^n} EU_H^L(e_0)$).This condition is simplified since for $c > \frac{3-6\theta}{-3-4\theta+4\theta^2}$, the high type who is considered as low, always prefers lowest level of effort $e_0 = 0$.

high type, exerting maximum effort and hoping that the public signal contradicts her private beliefs. This is in contrast to being considered a low type, exerting no effort, and receiving a low policy choice. This explains why separation is not possible when the cost is below the cutoff $\bar{c}$.

Although both agent types have the same ex-ante preferences, the driving force behind separation is their divergent interests after observing their private signals. The divergence is primarily due to their opposite direct preferences for $m(e)$ and, consequently, effort. With a fixed decision rule, the high-type agent benefits from increasing effort, while the low-type agent's benefit decreases. This is because the agents have differing expectations regarding whether the public signal will align with their preferred policy $x = 1$.

Next, we turn our attention to characterizing semi-separating when the agent chooses the effort level.

4.2 Semi-Separating Equilibrium

Recall that $\bar{c}$ represents the exact cost at which the separating equilibrium involves no effort from the low type ($e_0^n = 0$) and maximum effort from the high type ($e_1^n = 1$). For $c < \bar{c}$, pure separation is no longer possible because, at this cost level, the low type has an incentive to deviate by exerting maximum effort and posing as a high type. Since we can't increase the effort of a high type (to make posing as a high type less attractive) or decrease the effort for the low type (to make truthfulness more appealing), one way to prevent the low type from having a profitable deviation while preserving some level of separation is through a semi-separating equilibrium. In the semi-separating equilibrium, the high type always chooses the maximum effort $e_1^n = 1$. The low type chooses the minimum effort $e_0^n = 0$ with probability $1 - \sigma$, and with probability σ, she pretends to be the high type by also exerting the maximum effort.

Proposition 2. *When the agent decides effort: a semi-separating equilibrium exists for intermediate costs $c \in (0.375(2\theta - 1), \bar{c})$. In this equilibrium, the high type exerts maximum effort $e_1^n = 1$, while the low type exerts no effort $e_1^n = 0$ with probability $1 - \sigma^*$ and maximum effort with probability σ^*. With off-path beliefs of the principal always being a low type, this equilibrium satisfies the Intuitive Criterion.*

Allowing the semi-separation decreases the policy choices made after observing high effort ($x_{11}(1)$ and $x_{10}(1)$ are both decreasing in σ).[11] Consequently, as σ increases, posing as a high type becomes less desirable. This allows us to have a semi-separating equilibrium for

[11] Since the low type sometimes pretends and exerts maximum effort, observing $e = 1$ becomes a weaker signal for a higher policy choice for the principal.

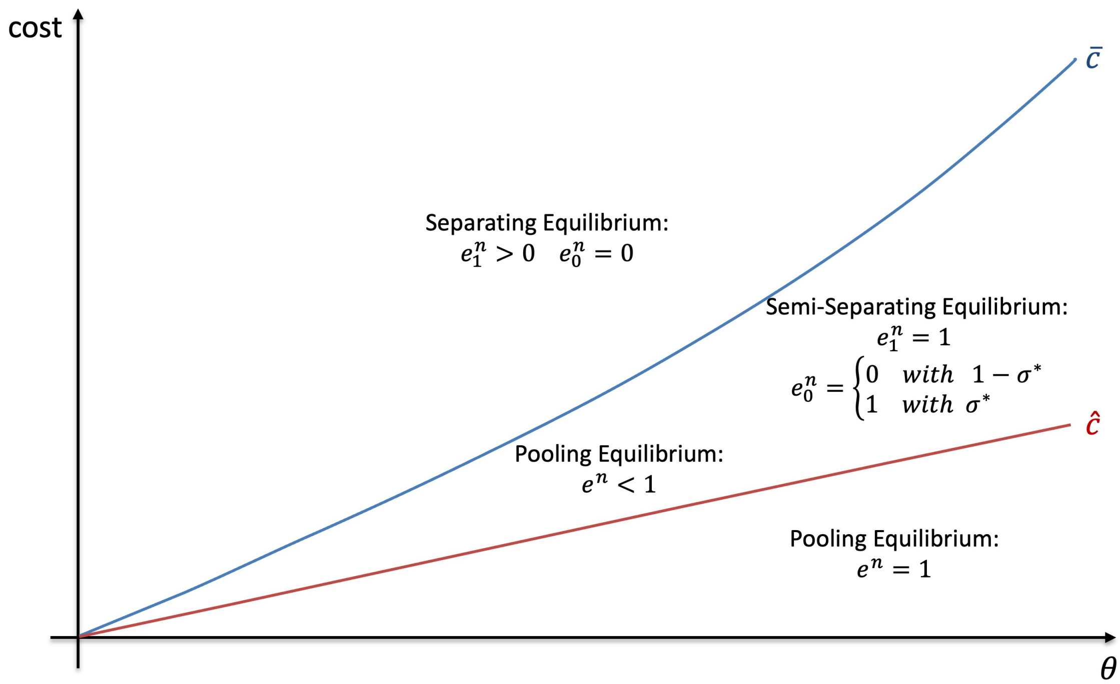

Figure 2: This figure illustrate the equilibrium effort levels from high and low type agents when the agent decides effort.

$c < \bar{c}$, where σ^* is the exact mixing probability that makes the low type indifferent between choosing the minimum or maximum effort levels. As c decreases, the cost of pretending to be a high type decreases. Consequently, σ^* increases to counteract this effect, by decreasing the benefit of posing as a high type. For $c = 0.375(2\theta - 1)$, we have $\sigma^* = 1$, meaning that the low type always chooses the highest effort level, thus transitioning to a pooling equilibrium at the maximum effort level.

4.3 Pooling Equilibria

There exist multiple pooling equilibria in this model, each supported by different off-path beliefs.[12] However, for the purpose of comparison with the main model where the principal determines the effort levels, we will focus on the best possible pooling equilibrium for the principal. In this equilibrium, pooling occurs at the highest possible effort level.

Given that being considered the low type is the most undesirable belief for the agent,

[12]One example of a trivial pooling equilibrium is when the agent always exerts zero effort in the public signal, regardless of her actual private signal. Consequently, the principal randomly selects a high or low policy with equal probabilities. In this case, the off-path beliefs of the principal assume that anyone exerting positive effort has a low private signal. It is important to note that this scenario represents the worst-case scenario for the principal since he receives no information (neither public nor private) and makes decisions solely based on his prior belief.

the easiest off-path beliefs to sustain the pooling equilibrium are those that consider anyone exerting effort $e \neq e^*$ to be the low type, where e^* represents the equilibrium pooling effort level.

Let $EU_L^P(e)$ denote the expected utility of the low-type agent when the principal assumes that the agent is pooling at effort level e. The first-order condition reveals that $EU_L^P(e)$ is strictly decreasing in effort, indicating that the low-type agent prefers to pool at the minimum effort level. In order to discourage the low-type agent from deviating from the pooling equilibrium according to our off-path beliefs, it is necessary to have $EU_L^P(e^*) \geq EU_L^L(0)$. It is sufficient to verify this condition for $e = 0$, given that we have already established that $EU_L^L(e)$ is decreasing in e. To achieve the best possible outcome for the principal, which entails pooling at the highest effort level, this condition should be satisfied with equality if and only if $e^* < 1$.

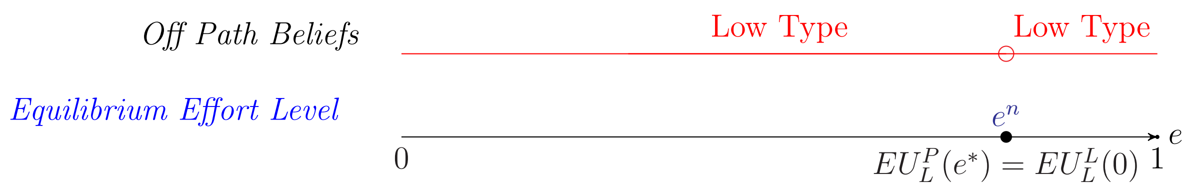

Figure 3: *This Figure shows the separating equilibrium when the agent decides effort, for intermediate cost* $\frac{3-6\theta}{-3-4\theta+4\theta^2} < c < \bar{c}$.

Lemma 1. *When the agent decides effort: pooling has to always occur at an effort level less than or equal to* e^**, with equality if there exists off-path beliefs that do not make high type want to deviate.*

$$e^* = \begin{cases} 1 & \text{if} \quad c \leq 0.375(2\theta - 1) \\ 2\sqrt{\frac{-1+2\theta}{-1+8c+2\theta}} & \text{if} \quad c > 0.375(2\theta - 1) \end{cases} .$$

Now, we formally present the pooling equilibria in this scenario:

Proposition 3. *When the agent determines the effort level: in the best pooling equilibrium for the principal, the agent pools at the same effort level* $e^n = e^*$ *as described in the previous lemma. The off-path beliefs of the principal assume that the agent is a low type. Additionally, for sufficiently low costs* ($c < \bar{c}$)*, where the separating equilibrium does not exist, this pooling equilibrium also satisfies the Intuitive Criterion.*

Establishing this as an equilibrium strategy involves demonstrating that the high type has no incentive to deviate and be perceived as a low type. In the described pooling equilibrium, the high type enjoys strictly higher utility than the low type, and since e^* is chosen to make the low type indifferent, the high type also has no desire to deviate. For $c < \bar{c}$, the low type is always better off deviating to any effort level $e \neq e^*$ if being perceived as a high type. Consequently, any off-path beliefs are not dominated by equilibrium strategies of the low type. Hence, the off-path beliefs that always assume the agent is the low type satisfy the Intuitive Criterion. (Note: The Appendix provides an explanation for why the Intuitive Criterion may fail for $c > \bar{c}$.)

For $c > \bar{c}$, e^* serves as the upper bound for the best pooling equilibrium that satisfies the Intuitive Criterion. However, even with this upper bound, we will demonstrate later that the principal benefits significantly from imposing formal requirements on the effort level invested in the public signal.

To summarize, when the agent decides the effort level: for costs low enough ($c \leq 0.375(2\theta - 1)$), we have a pooling equilibrium where everyone exerts the maximum effort. For intermediate costs ($c \in (0.375(2\theta - 1), \bar{c})$), we have a semi-separation where the high type exerts the maximum effort, while the low type mixes between no effort and maximum effort. Note that for these cost levels, there also exists a pooling equilibrium where pooling occurs on the intermediate effort level. Comparison between pooling and semi-separating equilibria for the principle is not trivial. In general, the principal prefers semi-separation for higher level of expertise (θ) and higher cost of public signal (c). Finally, for costs high enough ($c \geq \bar{c}$), we have a separating equilibrium where the low type exerts no effort, while the high type exerts just enough effort to differentiate herself from the low type.

5 Formal Requirements

Now we consider the scenario where the principal has the ability to request different effort levels from the agent, but lacks credible commitment to an arbitrary decision rule. In the context of the RUC, it is reasonable for the committee to demand a certain number of surveys based on the soft information provided by the proposer. Once both soft and hard information have been provided, the committee is expected to make an "interim rational" decision. The principal's policy choice will be influenced by their posterior belief regarding the state being high, which is derived from the reported private signal $\tilde{s}$ and public information i, given the required effort level $e(\tilde{s})$. Consequently, if the principal believes the agent's private report, policy choices will align with those described in Claim 1: $X^* = \{x_{00}, x_{01}, x_{10}, x_{11}\}$.

The principal determines the required effort levels following low and high reports from the agent. There are two possibilities: either the principal demands the same level of effort regardless of the agent's report, denoted as $e_0 = e_1 \equiv e$ (pooling), or the principal specifies different effort levels based on the agent's private reports, denoted as $e_0 \neq e_1$ (separation). We restrict attention to pure strategies so equilibrium characterization below is given for only pure separation.

Optimal Pooling Requirement

The analysis of this case is straightforward. If the principal requires the same effort level from both types, the reports from the agents become mere cheap talk. When the principal mandates a single effort level, they should disregard the private reports and base their decision solely on the observed public signal. Consequently, after observing low and high public signals, the principal's policy decisions will be $x_0 = 1 - m(e)$ and $x_1 = m(e)$. Since the principal's policy decision relies exclusively on the public signal, and the cost of obtaining the public signal is borne by the agent, we can readily characterize the optimal pooling effort for the principal:

Lemma 2. *When the principal imposes a single requirement on the effort level for public information for both types of the agent, they always demand a maximum effort level $e^r = 1$, and make the policy decision solely based on the observed public signal.*

This result is trivial, as in the case of pooling, the principal only considers the public signal, and thus desires it to be as accurate as possible.

Optimal Separating Requirement

Since our focus is solely on pure strategies, this section considers full separation, where the principal mandates two distinct effort levels and agent types do not mix.[13] The principal's problem can be formulated as follows:

$$\max_{e_0, e_1} EU_p(e_0, e_1)$$

Subject to two intensive compatibility (IC) constraints for each type of the agent:

$$\begin{aligned} IC_0: \qquad & EU_L^L(e_0) \geq EU_L^H(e_1) \\ IC_1: \qquad & EU_H^H(e_1) \geq EU_H^L(e_0). \end{aligned}$$

It is crucial to bear in mind that this problem revolves around mechanism design with limited commitment. The principal possesses full authority to demand a specific level of

[13] Pure strategies allow us to focus on truthful revelation of the agent's type in a separating equilibrium $\tilde{s} = s$.

effort from the agent. In the case of the RUC, for instance, the committee can establish stringent rules regarding the number of questionnaires that must accompany each proposal. We assume that the agent has no alternative but to exert one of the two required effort levels; failure to do so would result in proposal rejection and potential termination. Two incentive compatibility constraints ensure that the agent selects the "correct effort" based on her private signal.

Given that the objective function exhibits increasing returns with respect to both effort levels, e_0 and e_1—as effort enhances the precision of the public signal, leading to improved policy choices for the principal—we can focus our attention on satisfying the incentive compatibility constraints. In the case of the RUC, the committee desires to obtain as many questionnaires as possible with each proposal. However, they also aim to utilize effort to extract private expert opinions from the proposer. If every proposal necessitated the maximum number of questionnaires, the proposer would consistently claim that the procedure is arduous, resulting in a return to the previous pooling case.

Lemma 3. *When the principal imposes formal requirement that induce separation, for the optimal effort levels, the IC constraint of the low agent is binding and the IC constraint of the high type is slack.*

Intuitively, if IC_0 does not bind and the low agent does not exert maximum effort $e_0 < 1$, then the principal would benefit from increasing e_0 by a small amount ϵ. Additionally, the low-type agent cannot exert maximum effort since doing so would violate her IC_0. For the low type agent, being required to exert maximum effort is the worst-case scenario because it results in lower expected utility compared to the high type agent ($EU_L^L(1) < EU_L^H(e_1)$ for any e_1). Furthermore, given the specified cutoffs and the condition $e_0 \neq e_1$, it is not possible for both incentive compatibility constraints to bind, making IC_1 slack.

This lemma demonstrates that in separating equilibria, the principal places a primary focus on satisfying the incentive compatibility constraint of the low agent, as this agent has the strongest incentive to conceal her private information. In the case of the RUC, the proposer who believes, based on her professional opinion, that the medical procedure is easy is more likely to lie in order to increase the final price. She is also inclined to exert less effort in the public signal, as the questionnaires would align with her private opinion and lead to a decrease in price. On the other hand, the proposer who genuinely believes, based on her professional opinion, that the procedure is difficult will never lie by stating the opposite. Moreover, she is more willing to provide additional questionnaires to substantiate her case.

Corollary 2. *When the principal imposes formal requirements and induces separation, the optimal strategy requires a high-type agent to exert maximum effort, i.e.,* $e_1 = 1$.

This result directly follows from the previous lemma. If IC_1 is not binding, then increasing the optimal effort level e_1 by a small amount ϵ does not violate any incentive compatibility constraints and actually improves the objective function. This leads to a contradiction, indicating that the optimal effort level for the high type agent must be equal to or greater than 1. Intuitively, even though the public signal is costly, the high type agent is more willing to exert higher effort because she believes the public signal will support her claim and result in a higher policy choice.

By substituting these findings into IC_0 and solving for e_0, we can determine the optimal solution for this case.

Proposition 4. *If the principal imposes formal requirements on the effort level for the public signal, separation is only possible for $c > \bar{c}$. Moreover, the optimal effort levels in this case are: maximum effort for the high type $e_1^r = 1$ and intermediate effort $e_0^r < 1$ for the low type.*

This proposition demonstrates that, similar to the case when the agent decides the effort level, the principal can only achieve separation by imposing formal requirements when the cost is sufficiently high. The effort levels serve two purposes for the principal: increasing effort enhances the precision of the public signal, leading to better decision rules, and effort requirements are used to ensure the agent's incentive compatibility and extract their private information. The optimal strategy, when separation is feasible, follows an intuitive structure. When the agent reports a low private signal, she deviates from her preferences and is rewarded by being required to exert less effort in the public signal. On the other hand, the agent with a high private report is obligated to provide maximum effort in the public signal to support her proposal. As the cost increases, formal requirements on effort become more effective tool for inducing separation, resulting in an increase in the required effort level for the low-type agent. We have now characterized the optimal strategies for the required effort in both the separating and pooling cases. In equilibrium, the principal will evaluate his expected utility from both of these strategies and make a decision accordingly.

Equilibrium

Now we proceed to fully characterize the equilibrium of the model with formal requirements by comparing the expected utilities from the optimal strategies in the pooling and separating cases that were derived above: $EU_p(e_0 = e_1 = 1)$ and $EU_p(e_0^r, e_1^r = 1)$.

Proposition 5. *If we restrict attention to pure strategies, equilibrium with formal requirements is the following:*

- *For* $\left[\theta < \bar{\theta} \text{ and } c < \tilde{c}\right]$ *or* $\left[\theta > \bar{\theta} \text{ and } c < \bar{c}\right]$*: the principal imposes the same maximum effort level after both private reports and the policy decision is made solely based on the public signal. Every agent exerts this required effort level regardless of their type.*
- *For* $\left[\theta \leq \bar{\theta} \text{ and } c \geq \tilde{c}\right]$ *or* $\left[\theta \geq \bar{\theta} \text{ and } c \geq \bar{c}\right]$*: the principal imposes maximum effort level after the high private report* $e_1^r = 1$ *and intermediate effort level after the low private report* $e_0^r < 1$*. The agent chooses effort level corresponding to her private signal.*

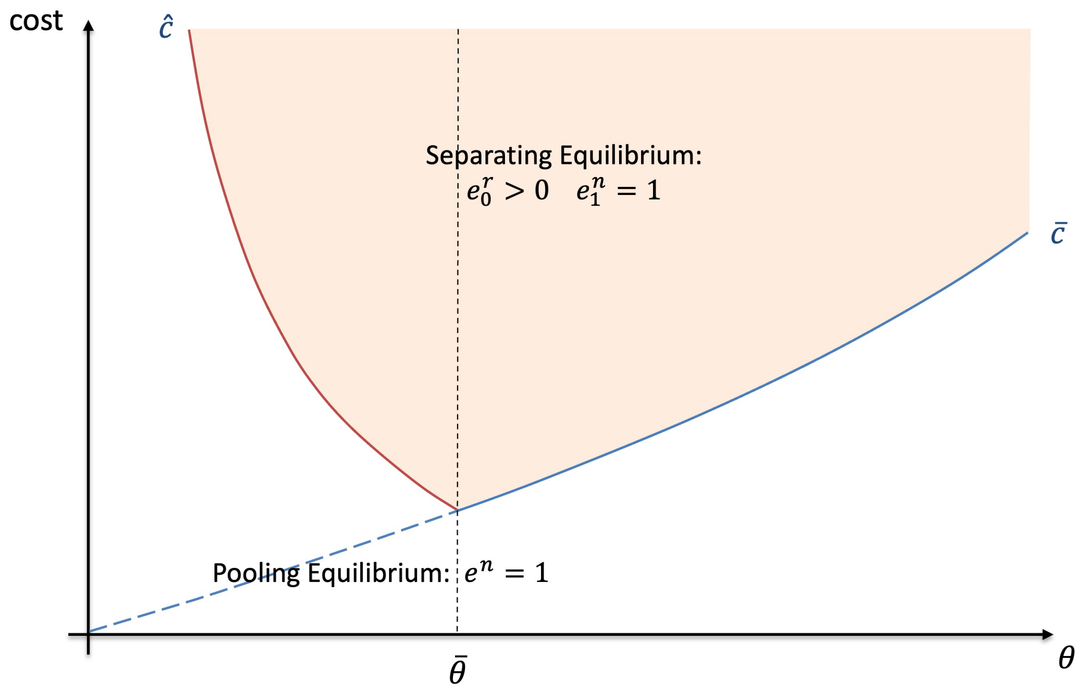

Figure 4: This figure shows equilibrium with formal requirements. For low enough costs, both agents exert maximum effort and the principal follows only the public signal. For high costs, the high-type agent exerts maximum effort and the low-type agent exerts intermediate effort level.

The equilibrium in the white region of the graph corresponds to pooling at the maximum effort level, where every proposal is required to have the maximum number of questionnaires filled out. The final policy choice is solely based on the results of the questionnaires, disregarding the professional opinion of the proposer as cheap talk.

There are two different situations in this case. First, when the cost of acquiring additional information is not high enough to satisfy the incentive compatibility of the low-type agent, even when the high-type agent is required maximum effort and the low-type is required no effort ($c < \bar{c}$). As a result, the principal disregards the reported private signal from the agent, always requiring the maximum amount of effort, and makes a decision solely based on this information. In the RUC example, this means that the cost of filling out surveys and providing hard information is so low that it does not provide enough leverage for the committee to extract private information from the proposer. Therefore, the RUC requires the maximum number of surveys and makes a decision based only on this "hard information."

Second, when the cost is high enough ($c \in (\bar{c}, \tilde{c})$) to induce separation, but the separation is not worth it. In this case, the principal has to incentivize the low-type agent by decreasing the required effort level for her. However, for low enough θ and cost, the precision sacrificed in the public signal after a low private signal is significant, making it not worth learning the private signal of a relatively incompetent agent. As a result, even though separation is possible, the principal always requires the same maximum level of effort from the agent, and the final decision is made solely based on the public signal.

On the other hand, the equilibrium in the highlighted region of the graph exhibits a separating structure. In this region, the optimal strategy with formal requirements involves requiring the agent with a high private signal to exert maximum effort in the public signal, while the agent with a low private signal exerts an interim level of effort. This corresponds to a situation where the cost is high enough to give leverage to the principal for extracting private information. In our example, for these parameters, the proposer truthfully reports her professional opinion. If this opinion supports high prices, the principal requires the maximum amount of public information (surveys), while the low agent is asked to exert intermediate effort. In both cases, the principal makes a final decision based on his updated posterior, after observing all the information. It is worth noting that e_0 increases with the cost c. This result is intuitive, as a higher cost gives more leverage to the principal, enabling him to require more hard information.

Next, we conduct a welfare comparison between the two models to assess the advantages of formal requirements for the principal.

6 Welfare Comparison

Observation 6. *The principal always weakly (and sometimes strictly) benefits from imposing formal requirements on the amount of hard information acquired.*

Observation 6 reveals that the relationship between the expected utilities depicted on the graph holds for general parameters. This finding carries direct policy implications for the case of the RUC. As mentioned earlier, the current procedure imposes no restriction on the number of surveys the proposer must provide to support her proposal. Our analysis demonstrates that even in the best-case scenario for the principal (favoring the principal in our equilibrium selection), he would achieve superior outcomes by implementing formal requirements on the number of surveys needed to support the proposal. Theoretically, this result is not particularly surprising since granting more power to the principal naturally improves his expected utility in equilibrium. What is more intriguing is to examine the circumstances under which this "power" to impose formal requirements truly generates substantial benefits and how precisely the principal leverages it to enhance his welfare.

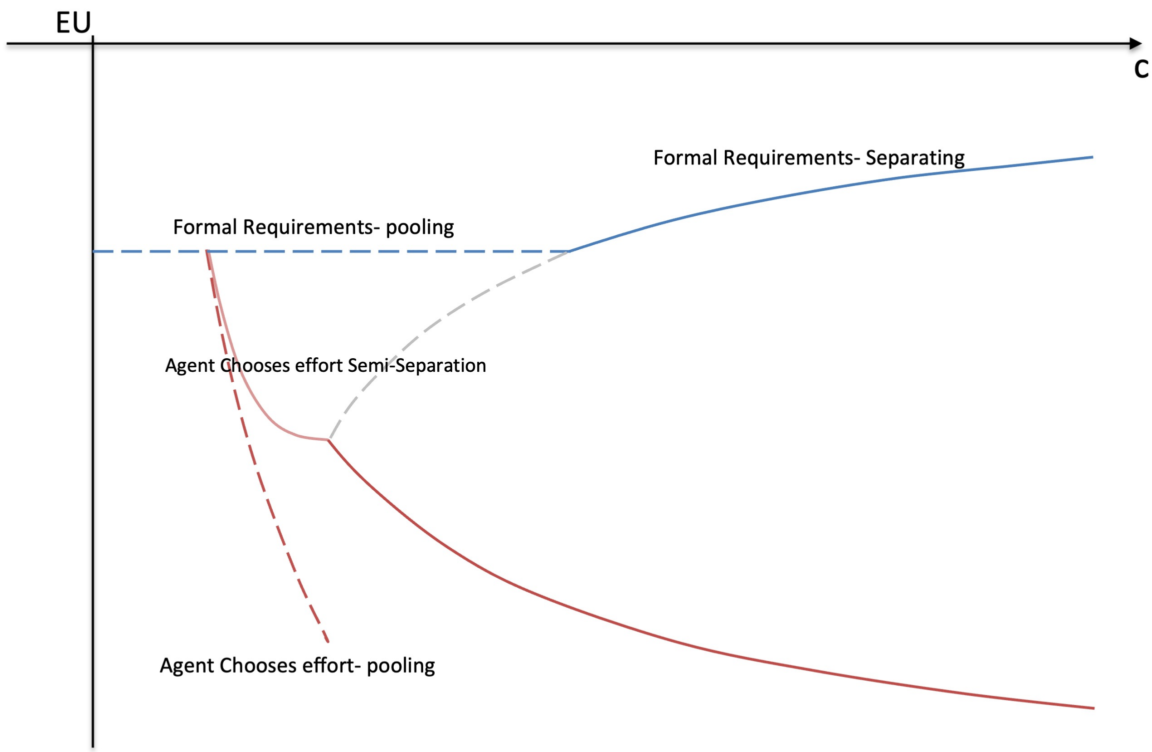

Figure 5: Expected Utilities of the Principal in Equilibria: $\theta = 0.65$

Let us further discuss when and how formal requirements actually help the principal. The graph below illustrates the relationship between the expected utilities of the principal in equilibria of the two models: one with formal requirements (blue line) and one without formal requirements (red line) for $\theta = 0.65$. Dotted lines represent pooling cases, while the solid line refers to the separating equilibria.

For extremely **low cost of effort** ($c \leq 0.375(2\theta - 1)$), separation is neither possible nor desirable. Regardless of who controls the effort level, the agent always exerts maximum effort, and the policy decision is made solely based on public information (recall that without formal requirements, we selected the best possible equilibria for the principal).

When **the cost is intermediate** ($0.375(2\theta - 1) < c \leq \bar{c}$), separation is still not possible, but formal requirements yield a direct benefit for the principal by imposing maximum effort in the public signal. Meanwhile, if the agent chooses the effort level, she still plays the pooling equilibrium, but pooling occurs at an interim effort level. Without formal requirements, the low-type agent would prefer to deviate and reveal her private signal rather than exert maximum pooling effort. This is the first and direct benefit of formal requirements (the difference between the blue and red dotted lines): requiring more effort leads to a more informative public signal and better policy choices for the principal. This is also the region where semi-separating equilibrium exists: the high type maximum effort, while the low type mixes between no effort and maximum effort. Observe that for this particular value of θ, principal prefers semi-separating equilibrium to pooling equilibrium.

When **the cost is high enough ($c > \bar{c}$)**, separation can be achieved in both models. However, this does not mean that when the principal controls the effort level, he would always prefer separation. In fact, we chose this particular value of θ to illustrate another interesting feature of the equilibria. For $c \in (\bar{c}, \tilde{c})$, in the best equilibrium for the principal when the agent controls the effort level, the agent plays a separating strategy, revealing her soft information. However, for these parameters, the principal would rather ignore private signals altogether and make a decision based solely on the maximum required hard information (the area with the gray dotted line on the graph). This occurs when θ is small enough that the soft information is not highly valuable, and the cost is intermediate, so the high-type agent would use the soft information to separate themselves from the low-type agent if they were allowed to choose their own effort levels. When the principal imposes formal requirements, he could induce separation by satisfying the incentive compatibility constraints of the agents. However, with the intermediate cost, this would mean letting the low type off the hook by requiring a relatively lower effort ($e_0^r < 1$). In combination with a weak private signal (θ small enough), this does not make separation worth forgoing hard information from the low type. Therefore, the principal would rather ignore the private reports and make a decision based on the maximum possible effort in hard information. This is an example where the benefit of formal requirements comes from the direct benefit of increased informativeness of the public signal (the difference between the gray and red dotted lines), as well as the possibility of changing the type of equilibrium from separating to pooling (the difference between the blue dotted and gray lines).

For **high enough cost ($c > \bar{c}$)**, both models have a separating equilibrium, but the principal is strictly better off with formal requirements. This example provides interesting insight into how formal requirements are used by the principal to achieve higher utility. The expected utility from separation in both models starts out with the same pure separation: no effort for the low agent and maximum effort for the high agent (the red solid and gray dotted lines start from the same point). As the cost increases, the high type can more easily separate themselves even with a lower effort level, and e_1^n decreases. This is why the expected utility of the principal (the red solid line on the graph) decreases with cost.

On the contrary, in the main model with formal requirements, the effort levels are used to extract soft information s and collect the maximum possible hard information (higher effort means a more precise public signal i). As the cost increases, the effort becomes a more effective mechanism for the principal to impose separation. He requires maximum effort from the high type and can now increase the required effort for the low type as well, without violating her incentive compatibility constraint. Therefore, the difference between the effort levels shrinks with higher cost, and e_0^r slowly converges to $e_1^r = 1$. This is why the expected utility of the principal (the gray dotted line and blue solid line) increases with cost.

7 Conclusion

In conclusion, this paper addresses the shortcomings in the operating procedures of federal advisory committees and proposes formal requirements as a potential solution to improve biased policy recommendations. Although our research focuses on advisory committees, our findings have broader applicability to various principal-agent problems involving biased expert agents responsible for acquiring delegated information, as long as it is possible to mandate the acquisition of verifiable information at a cost.

To evaluate the benefits of formal requirements, we examine two variations of the model: one where the agent has discretion in choosing the effort level for public information (similar to the current practices of advisory committees), and another where the principal can impose formal requirements on the amount of public information to be gathered.

We have demonstrated that when the agent has control over her own effort levels, bias in her preferences can result in the potential for a separating equilibrium, given a sufficiently high cost. Although both agent types exhibit the same bias, the divergence in their interim preferences arises from observing different private signals. The disagreement primarily stems from their contrasting preferences regarding the informativeness of the public signal after observing the private signal. The low type expects a low public signal, leading to a low policy decision. Consequently, she prefers the public signal to be as unreliable as possible. On the other hand, the high type anticipates a high public signal, which results in a higher policy decision. Hence, the high type prefers a more reliable public signal, necessitating greater effort.

While separation is achievable when the agent controls the effort level, it is still driven by biased preferences, and the chosen effort levels are suboptimal for the principal. Interestingly, this remains true even when we select the most favorable equilibrium for the principal that satisfies the Intuitive Criterion. In fact, if an agent's competence is sufficiently low, they might willingly separate themselves, but the principal would prefer to maximize the public signal and disregard their private reports by pooling at the highest effort level.

The primary objective of this paper is to demonstrate that if the principal assumes control and imposes formal requirements on the agent, fairness in outcomes can be enhanced. Our analysis affirms that this is indeed the case. By implementing formal requirements on effort, the principal not only gains a direct benefit from a more informative public signal but also accurately aligns the preferences of the biased agents. The optimal mechanism rewards a low private report by requiring a lower effort level for the public signal, while high reports necessitate maximum effort. Welfare comparisons consistently reveal that the principal achieves better outcomes, when separation is feasible. This finding carries significant policy implications for our specific application, highlighting the inefficiency of the current procedure and the potential for substantial improvements in price fairness through the introduction of formal requirements.

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A Appendix

Proof of Observation 5

Proof If the low-type agent is treated as a high type for effort level e_1, her expected utility equals to:

$$EU_L^H = \underbrace{-\Big[P(i=0|s=0)(1-x_{10}) + P(i=1|s=0)(1-x_{11})\Big]}_{B_L^H} - \underbrace{ce_1^2}_{C_L^H}.$$

The cost C_L^H is trivially increasing in effort e_1. Therefore we only need to show that B_L^H is decreasing in e_1. Substituting the values of x_{10}, x_{11} and $m(e_1)$ and derivating it with respect to e_1 gives us:

$$\frac{\partial B_L^H}{\partial e_1} = \frac{e_1\theta(2-6\theta+4\theta^2)}{(-1+e_1^2(0.5-\theta)^2)^2} < 0.$$

Observe that for $\theta \in (0.5, 1)$ we always have $2 - 6\theta + 4\theta^2 < 0$ and therefore the benefit as well as overall expected utility of the low agent when treated as high is decreasing in e_1.

Proof of Proposition 1

Proof We have already discuss a few important observations in the main text needed for this proof:

1 In equilibrium, low type exerts no effort $e_0^n = 0$.

2 EU_L^H is decreasing in e_1.

3 e_1^n is the lowest effort level for which the principal believes the agent is a high type.

4 In separating equilibrium $EU_L^L(e_0^n) \geq EU_L^H(e_1^n)$, with equality if the off path beliefs satisfy the Intuitive Criterion.

First we prove that separating equilibrium cannot exist for $c < \bar{c}$. From observations above we know that in order for the low type not to have an incentive to deviate in equilibrium, we must have $EU_L^L(e_0^n = 0) = -\theta \geq EU_L^H(e_1^n)$. Moreover, $EU_L^H(e_1^n = 0) = -(1-\theta) > -\theta = EU_L^L(e_0^n = 0)$, $EU_L^H(e_1^n)$ is decreasing in e_1^n and $EU_L^L(e_0^n = 0) = -\theta$ is constant in e_1^n. Consequently, the condition for the low type stated above can never be satisfied if $EU_L^H(e_1^n = 1) > -\theta$ which implies that in order for the separating equilibrium to exist, we must have $c > \bar{c}$. Since, $EU_L^H(e_1^n)$ is strictly decreasing in e_1^n, this also proves that there is an unique value of $e_1^n \in (0,1]$ for separating equilibrium satisfying the Intuitive Criterion.

We have already shown that these equilibrium quantities are feasible, and the low type has no incentive to deviate. As for the high type, since EU_H^H is decreasing, she never has the incentive to deviate to the effort levels where the principal correctly believes her type $e > e_1^n$. When the high type is treated as a low type, $EU_L^L(e_0^n = 0) = EU_L^H(e_1^n) < EU_H^H(e_1^n)$[14] and $EU_L^L(e_0^n = 0) = EU_H^L(e_0^n = 0) = -\theta$. This means that if the high type was considered to be a low type, she does not want to deviate to $e_0^n = 0$. We now only need to show that for $c > \bar{c}$, $EU_H^L(e)$ is a decreasing function so the high type does not want to deviate to $e \in (0, e_1^n)$.

$$EU_H^L = \underbrace{-\Big[P(i=0|s=1)(1-x_{00}) + P(i=1|s=1)(1-x_{01})\Big]}_{B_H^L} - \underbrace{ce_0^2}_{C_H^L}.$$

Unlike the case with the low type treated as high, the benefit of the high type treated as a low B_H^L is actually increasing in e_0. This is again because of the fact that the high type expects public signal to increase the policy choice. Overall,

$$\frac{\partial EU_H^L}{\partial e_0} = \frac{e_0}{(-1+e_0^2(0.5-\theta)^4}\Bigg(c\underbrace{(-2+4e_0^2(0.5-\theta)^2 - 2e_0^4(0.5-\theta)^4)}_{<0} + \underbrace{\theta(-2+6\theta-4.\theta^2)}_{>0}\Bigg)$$

Note that this value is decreasing in cost and increasing in $e_0 \in (0,1)$. Therefore we simply check that $\frac{\partial EU_H^L}{\partial e_0} < 0$ for $c = \bar{c}$ and $e_0 = 1$, which is always the case for $\theta \in (0.5, 1)$. This proves that the high type would not want to deviate to any effort level $e \in (0, e_1^n)$. [15]

Now we only need to verify that this equilibrium satisfies the Intuitive Criterion. Since EU_L^H is decreasing in e and e_1^n makes the low type indifferent, any belief $e \in (0, e_1^n)$ is not equilibrium dominated. Therefore, the principal's beliefs that the agent is a low type when deviating to $e \in (0, e_1^n)$ satisfies the Intuitive Criterion. For $e > e_1^n$, we have equilibrium dominated for both types and therefore any belief would satisfy Intuitive Criterion on this region. This completes our proof.

Proof of Proposition 2

Proof First we need to establish what the equilibrium mixing probability is. The following condition should be satisfied for the low type in order her to be indifferent between choosing

[14] Last inequality is satisfied for any positive effort level since the high type expects public signal to agree with her private signal while the low type expects the public signal to point towards lower state of the world.

[15] An interesting observation to make is that, since the derivative is increasing in $e_0 \in (0,1)$, EU_H^L cannot have an interior maximizer for $e_0 \in [0,1]$.

$e_0 = 0$ or $e_1 = 1$:

$$EU_L^L(e_0 = 0, \sigma) = -P(i = 0|s = 0)(1 - x_{00}) - P(i = 1|s = 0)(1 - x_{01}) - c0^2 =$$
$$-P(i = 0|s = 0)(1 - x_{10}) - P(i = 1|s = 0)(1 - x_{11}) - c1^2 = EU_L^H(e_1 = 1, \sigma)$$

Observe that x_{ij} depends on effort levels as well as the mixing probability σ. Substituting the values of these policy choices (using Bayes' Rule) and simplifying the equation gives us:

$$EU_L^L(e_0 = 0) = -\theta$$

as for $EU_L^H(e_1 = 1, \sigma)$, FOC reveals that it is monotonically decreasing in σ. This is intuitive since higher σ decreases the policy choices after choosing the maximum effort. When $c < 0.375(2\theta-1)$, even for $\sigma = 1$, the low type strictly prefers exerting maximum effort. Similarly for $c > \bar{c}$, even for $\sigma = 0$ the low type strictly prefers to exert no effort. For the cost levels between these two values, there is a unique σ^* that solves the equality above. Since $EU_L^L(e_0)$ is decreasing in effort and the principal's off path believes are low, the low type agent does not want to deviate off path either.

Now we only need to verify that high type does not want to deviate. If she deviates to any other effort level than $e = 1$, the principal believes they are a low type. $EU_H^L(e_0)$ is decreasing in e_0, meaning when the principal treats high type as a low, she prefers to exert minimum effort. So we only need to verify that $EU_H^H(e_1 = 1, \sigma^*) > EU_H^L(e_0, \sigma^*)$ which is always satisfied for σ^* derived above. Verifying the Intuitive Criterion for this case is the same as for the case of pure separation for $c = \bar{c}$.

Proof of Lemma 1

Proof Since being considered as a low type is the worse possible case for the agent, in pooling equilibrium, the low-type agent should be weakly better off than at her ideal point when considered as low type. We have already established that the low agent when perceived as low maximizes her expected utility when $e = 0$, and this maximum utility is $EU_L^L(e = 0) = -\theta$. In pooling equilibrium, low-type agent's expected utility is

$$EU_L^P = \underbrace{-\Big[P(i = 0|s = 0)m(e) + P(i = 1|s = 0)(1 - m(e))\Big]}_{B_L^P} - ce^2.$$

If we simplify this expression, we get that $B_L^P = -0.5 + e^2(0.125 - 0.25\theta)$ which is strictly decreasing in $e \in ([0, 1]$ since $\theta > 0.5$. This result is not surprising since the decision is made just based on the public signal and low type expects public signal to be low. For higher effort level, low public signal will decrease policy choice even more. Since the cost of effort is increasing, the low type wants to exert as little effort as possible in pooling equilibrium.

EU_L^P is decreasing in e and c and we must have $EU_L^P \geq -\theta$. For $c \leq 0.125(-3+6\theta)$, this inequality is satisfied for any e. Since we are considering the best possible equilibrium for the principal, we could have pooling at the maximum level without violating the incentive compatibility of the low type when considered low. For $c > 0.125(-3+6\theta)$, the inequality is satisfied i.f.f. $e \leq 2\sqrt{\frac{-1+2\theta}{-1+8c+2\theta}}$[16].

Proof of Proposition 3

Proof We have already shown that this strategy is feasible and the low-type agent has no profitable deviation. We only need to make sure that high type when considered as low does not want to deviate from the equilibrium pooling level of effort. In previous proofs we have already established that if the high type is considered as low, her expected utility is maximized at the border $e_0 = 0$ or $e_0 = 1$. Therefore, we only need to check incentive compatibility of the high type at these two effort levels.

$EU_H^L(e_0 = 0) = EU_L^L(e_0 = 0) = -\theta$ and for the same effort level, in pooling equilibrium the high type gets strictly higher utility $EU_L^P(e) < EU_H^P(e)$. Therefore, since e^* makes the low type weakly better off than exerting no effort and being considered as low, the high type will also be better off for this equilibrium pooling level e^*.

Similar to previous proposition, it is easy to verify that for $c > 0.125(-3+6\theta)$, $EU_H^L(e_0)$ is decreasing in e_0, therefore we do not need to compare equilibrium expected value to $e_0 = 1$. For $c > 0.125(-3+6\theta)$, $EU_H^L(e_0)$, we have $e = 1$ and comparing to $e_0 = 1$ is trivial since for a fixed effort level both types are better if the principal disregards the private reports than considers her to be the low type. Therefore, high type has no profitable deviation.

Now we show that for $c < \bar{c}$ this pooling equilibrium satisfies the Intuitive Criterion. For such a cost level, we know that for any effort level e, the low type is strictly better off being considered a high type than exerting no effort and being considered as low type (or exert equilibrium pooling level). Therefore, for low type all of the effort levels are not equilibrium dominated and our beliefs satisfy the Intuitive Criterion.

Proof of Lemma 2

[16] Observe that this value is always between 0 and 1 for $c > 0.125(-3+6\theta)$ and $\theta > 0.5$.

Proof The objective function of the principal is to maximize:

$$\max_{e\in[0,1]} \quad EU_P^r = -P(i=1)\Big[P(\omega=1|i=1)(1-x_1)^2 + P(\omega=0|i=1)x_1^2\Big] - $$
$$-P(i=0)\Big[P(\omega=1|i=0)(1-x_0)^2 + P(\omega=0|i=0)x_0^2\Big].$$

From earlier we already know that $x_0 = 1 - m(e)$ and $x_1 = m(e)$. Simplifying this objective function and substituting the values of x_0, x_1 and $m(e)$, we get that $EU_P^r(e) = -0.25 + 0.0625e^2$. This function is increasing in e for $e \in [0,1]$ and it is trivially maximized at $e^r = 1$.

Proof of Lemma 3

Proof The Incentive Compatibility constraints for each realization of the private signal s are:

$$IC_1: \quad EU_L^L(e_0) = -P(i=0|s=0)(1-x_{00}) - P(i=1|s=0)(1-x_{01}) - ce_0^2 \geq$$
$$-P(i=0|s=0)(1-x_{10}) - P(i=1|s=0)(1-x_{11}) - ce_1^2 = EU_L^H(e_1);$$
$$IC_2: \quad EU_H^H(e_1) = -P(i=0|s=1)(1-x_{10}) - P(i=1|s=1)(1-x_{11}) - ce_1^2 \geq$$
$$-P(i=0|s=1)(1-x_{00}) - P(i=1|s=1)(1-x_{01}) - ce_0^2 = EU_H^L(e_0).$$

We have already established the following facts:

1) $EU_L^L(e_0), EU_L^H(e_1)$ and $EU_H^H(e_1)$ are decreasing in effort levels.

2) $EU_H^L(e_0)$ is decreasing in e_0 for high enough cost, and it is always maximized at the border.

If we substitute values of x_{ij} and $m(e)$ is the objective function we trivially get that the expected utility of the principal is increasing in both e_0 and e_1. Meaning, the principal who imposes different effort levels, always wants to increase the effort levels as much as possible after each private signal (if the agent is truthful).

Now we prove why the IC of the low type is binding for optimal effort levels. There are several possible cases:

- Both IC constraints are binding. If both constraints bind then we should have $EU_L^L(e_0) + EU_H^H(e_1) = EU_L^H(e_1) + EU_H^L(e_0)$. If we simplify this condition we get

$$(e_1^2 - e_0^2)\theta(1 - 3\theta + 2\theta^2) = 0.$$

Since for separating case we have $e_1 \neq e_0$, both effort levels are positive and $\theta \in (0.5, 1])$, this condition can never be satisfied. Therefore, both IC constraints cannot bind.

- Trivially both IC constraints cannot be slack. In this case we could increase the effort level e_0 or e_1 (whichever is not at the maximum level) by ϵ small enough and it will not violate either IC constraints but will increase the value of the objective function.

- IC constraint of the high agent is binding and IC constraint of the low agent is slack. We can show that IC of the high type can only be binding for $c > -1+2\theta$. If the cost is lower than this value even for the highest (worst) effort level e_1, the high type strictly wants to be truthful.[17] For this high cost, $EU_H^L(e_0 = 0)$ is decreasing in e_0. Now we cannot have $e_0 = 1$ otherwise the IC constraint of the low agent would be violated (it is the worst case to be considered a low type and be forced to exert maximum effort). In this case, by increasing e_0 with ϵ small enough would not violate IC constraint of either type but increase the objective function. Therefore, in equilibrium this case is not possible either.

The only possible case left is that when the principal imposes different effort levels depending on the private report, for the optimal effort levels, the IC constraint of the low type is binding and IC of the high type is slack.

Corollary 2 When the principal imposing formal requirements induces the separation, the optimal strategy requires high agent to exert maximum effort, i.e., $e_1 = 1$.

Proof This directly follows from the previous lemma. If $e_1 < 1$, we can increase e_1 with ϵ small enough. It will not violate IC low since $EU_L^H(e_1)$ is decreasing in e_1 and will not violate IC high since the incentive compatibility constraint of the high agent is slack. However, increasing e_1 would increase the objective function giving us the contradiction.

Proof of Proposition 4

Proof We have already established that in this case, the IC constraint of the low-type agent is binding, the IC constraint of the low-type agent is slack, and $e_1 = 1$. The low-type agent's IC constraints becomes:

$$EU_L^L(e_0) = -q - ce_0^2 = B_L^H(e_1 = 1) - c = EU_L^H(e_1 = 1)$$

Observe that RHS is constant in e_0 while the LHS is strictly decreasing. Moreover, for $e_0 = 1$ we trivially have $EU_L^L(e_0 = 1) < EU_L^H(e_1 = 1)$, while $EU_L^L(e_0 = 0) >= EU_L^H(e_1 =$

[17] $EU_H^L(e_0)$ is maximized at the border. We trivially have $EU_H^H(e_1 = 1) > EU_H^L(e_0 = 1)$ since being considered a high type for the same effort level is strictly better. We have $EU_H^H(e_1 = 1) > EU_H^L(e_0 = 0)$ for $c < -1 + 2\theta$.

1) $\iff c > \bar{c}$.[18] Therefore, separation is only possible for $c > \bar{c}$ and there is an unique value of $e_0 \in [0, 1)$ that makes the low type indifferent. This proves that e_0^r is feasible and the IC constraint of the low type is satisfied. We also check that for $c > \bar{c}$ we also have $EU_H^H(e_1 = 1) > EU_H^L(e_0 = e_0^r)$. The effort levels described in the proposition are feasible, satisfy both incentive constraints, and are optimal based on the previous lemma and its corollary.

Proof of Proposition 5

Proof We have already shown the optimal strategies for separating and pooling cases. We need to show that the principal has no profitable deviation (from pooling to separating and vice versa). The principal's expected utility in pooling equilibrium does not depend on cost. Substituting the optimal maximum effort level, the principal in the optimal pooling case gets $EU^p(e^r = 1) = -0.1875$.

The principal can induce separation i.f.f. $c > \bar{c}$. Therefore, the equilibrium below this cost level is simply requiring maximum effort level after each private report. For $c > \bar{c}$, the principal's expected utility playing the optimal strategy with separation is $EU(e_0^r(c), 1)$. Even though the principal does not bare the cost of effort directly, this expected utility depends on c through the optimal effort after the low report $e_0^r(c)$.

We know that $e_0^r(c = \bar{c}) = 0$ and $e_0^r(c)$ is increasing in c. Since the principal always prefers more effort, $EU(e_0^r(c), 1)$ is also increasing in c. Moreover,when $c \to \infty \implies e_0^r(c) \to 1 \implies EU(e_0^r(c), 1) \to EU(e_0 = 1, e_1 = 1) > EU^p(e^r = 1)$. While $EU(e_0^r(\bar{c}), 1) = EU(0, 1) \leq -0.1875 \iff \theta \leq 0.698539 \equiv \bar{\theta}$.

Therefore, we get that for $\theta > 0.698539$, the optimal strategy in separation is always strictly better than the optimal strategy in pooling for the principal (whenever the separation is possible $c > \bar{c}$). For $\theta \leq 0.698539$, there is an unique $\tilde{c} > \bar{c}$ such that $EU(e_0^r(c), 1) > EU^p(e^r = 1) \iff c > \tilde{c}$.

To illustrate why the Intuitive Criterion might fail for $c > \bar{c}$, imagine an agent who deviates and exerts maximum effort level $e = 1$. Even if the low agent is considered to be the high type, she would not want to exert so much effort since (1) it is costly and (2) likely to agree with her low private signal leading to a lower policy choice. As for the high type, she actually benefits from investing in the public signal since it is likely to agree with her high private signal leading to a higher policy choice. If the cost is not too high, the high-type agent strictly wants to deviate to the maximum effort level when considered a high type, making $e = 1$ not equilibrium dominated for her. Off-path beliefs satisfying Intuitive

[18] Observe that this is the same threshold as before and allows the low agent not to have an incentive to deviate with $e_0 = 0, e_1 = 1$.

Criterion cannot put a positive probability on the agent who exerts $e = 1$ effort being a low type. But if the principal believes $e = 1$ comes from the high agent, the high type has a profitable deviation.