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CIDE

PERSUADING VOTERS: HARD FACTS, HARD TO HIDE

TESINA

QUE PARA OBTENER EL TÍTULO DE

LICENCIADO EN ECONOMÍA

PRESENTA

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Abstract

When a decision depends on others' opinions, it is better to have as much information as possible in order to make a better-informed decision. This thesis studies how information transmission occurs from an adviser to a group of voters or committee. Under this framework, the adviser and committee members share preferences but differ in opinions. The committee has to decide whether or not to implement a policy proposal whose convenience depends on an unknown state of the world. The adviser can endogenously acquire verifiable information; that is, if he transmits this information, he can not lie. Thus, the adviser has incentives to obtain information, and voters can always make an informed decision under this framework. Regarding welfare, the adviser prefers a voting rule such the pivotal voter ends up being the voter whose opinion is closer to the adviser's opinion. Such a voting rule results to be a simple majority rule. As a committee, voters should set a simple majority rule to incentivize the adviser to acquire as much information as possible and disclose it.

Keywords: Persuasion, Voters, Verifiable information
Clasificación JEL: D70, D72, D83

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Chapter 1

Introduction

When individuals have to make decisions, information plays an important role. Abundant and reliable information can lead to better decisions and better outcomes. Information might be more relevant when more than one individual is involved in the decision-making process since the ultimate action depends on others' opinions. Most of the time, this applies to politics and policy-making, for example, in committees and legislative bodies. Nevertheless, in most cases, information is costly to acquire for a single individual, i.e., a committee member, so it is common to rely on advisers. Most of the time, individuals might have particular interests, including advisers, that bias their actions. We might think that taking out of the equation possible interest bias might lead to better decisions per se. However, even when interests are shared, differences in opinions might lead to discrepancies, i.e., disagreements on determining the best way to address a problem.

Recent experiences illustrate this. For example, after the inauguration of a new administration in the White House in January 2021, the United States Congress resumed the discussion of the approval of a new economic relief package of 1.9 trillion dollars. This relief package aimed to alleviate the harm that the COVID-19 pandemic has done to American workers, families, and small businesses, among other sectors. All American Congress members probably agree that they should take some action; that is, they share a common interest (share preferences).

However, some partisan groups were skeptical that this economic aid would work in the current situation or that maybe it should have a smaller size; in other words, they do not share the same opinion about the gravity of the situation (the state of the world). Throughout most of 2020, governments around the world have faced similar decisions. The COVID-19 pandemic has pushed governments to make hard decisions, such as whether or not to impose national lockdowns, make mandatory face masks, close borders, and other restrictions for social distancing. Each decision comes with a cost, and having information on how the pandemic is evolving would help make the best choice. Despite its large capacity, it is common for governments to rely on experts on the topic to provide some guidance. For example, governments might rely on independent epidemiologists to provide data about COVID-19 cases, and that might indicate governments whether to keep restrictions or revoke them.

In both examples, having hard evidence would dissipate all doubts on how to proceed. The current thesis has the objective to study how information affects the decision-making of voters and the implications on their welfare. In particular, when information is hard facts and an informed adviser provides it. To address this question, the current dissertation develops a model based on Che and Kartik (2009). In the model of this thesis, an adviser (sender) can costly acquire verifiable information (hard facts) and can use it to influence a group of decision makers' (receivers) actions. The adviser and each voter share preferences but differ in opinions about an unknown state of the world and, hence, what action to take. As the main twist proposed here, the number of decision-makers is extended to a finite set of voters. Given a voting rule, those voters have to decide whether to approve or reject a policy proposal. Thus, the collection of actions changes from a continuum, as in Che and Kartik (2009), to just two possible actions. Additionally, it is paid special attention to how different voting rules affect the acquisition and provision of information as well as the decision-making process of the committee.

Under this framework, an adviser strategically conceals information from the committee whenever the electoral outcome is not in line with his opinions about the course of action. Since information is considered hard facts and there are only two actions, voters are skeptical about any adviser's claim on not having information. Voters' skepticism makes the committee harder to persuade, so it incentivizes the adviser to exert more effort. This result is in line with one of Che and Kartik (2009) main results, which shows that the difference in opinions between an adviser and a decision-maker incentivizes the adviser to put more effort in order to persuade the decision-maker.

The voting rule plays an important role too. For each voting rule, there is a pivotal voter who determines how hard it is for the adviser to persuade the committee. If the pivotal has closer opinions to the adviser's opinions, the adviser has a higher probability of persuading the committee. The adviser and the committee have a higher chance to agree on which action to take according to the information the adviser obtains. As long as the benefit of exerting more effort is larger than its cost, the adviser prefers a voting rule closer to the simple majority. Equivalently, voters as committee prefer a voting rule that incentivizes the adviser to put as much effort as possible and to disclose as much information he obtains. Consequently, voters prefer a voting rule close to the simple majority rule.

1.1 Literature review

This thesis relates to two major literature fields: strategic communication literature, in particular verifiable information, and voting literature. Verifiable information forms part of the strand of the literature on strategic communication, which also includes Bayesian Persuasion (see Kamenica and Gentzkow, 2011; Bergemann and Morris, 2016), cheap talk (see Crawford and Sobel, 1982; Green and Stockey, 2007), and signaling (see Spence, 1973), each with their specific applications. As a whole, strategic communication literature focuses on how a sender transmits information to a receiver. Particularly, in verifiable information, information is interpreted as hard facts: a receiver can verify or prove the veracity of the information she receives from a sender; so, the sender cannot lie; nevertheless, the sender can lie by omission, that is, he chooses not to tell the entire truth, but he can hide information he possesses. On the one hand, from verifiable information, we can find the seminal works of Milgrom (1981), Grossman (1981), and Grossman and Hart (1986). In those works, there are two agents, a sender and a receiver. The sender has private information about a relevant state of the world and can decide whether to disclose or conceal this information to the receiver. Usually, these hard facts are assumed to be exogenous.

On the other hand, Che and Kartik (2009) incorporate an endogenous and costly information acquisition process. Che and Kartik (2009) assume that an adviser (sender) and a decision-maker (receiver) share preferences but differ in beliefs. Moreover, both players' preferences depend on a relevant state of the world. In this thesis, both assumptions are considered, but as mentioned above, in the current work, there is a finite set, with cardinality higher than one, of voters who must aggregate their actions. Che and Kartik (2009) main results show that, despite sharing the same preferences, the difference in opinions works as an incentive for the adviser to acquire more information. Intuitively, an adviser who differs more in opinions might try to conceal information. Still, the decision-maker can protect herself by being skeptical when the adviser claims not to find hard facts. Argenziano, Severinov, and Squintani (2016) develop a model where a biased adviser can costly acquire information and transmit it to a decision-maker. The adviser can send messages which are interpreted as cheap talk. However, the decision-maker can still benefit from an adviser inside a cheap talk environment. The adviser can set a minimum quantity of information that the adviser must acquire to be listened to by the decision-maker.

Glazer and Rubinstein (2004) contemplate endogenous information acquisition too. In this case, a speaker (sender) can send two (or more) messages to a listener (receiver) from which the last one can only verify one of those messages. If the speaker's finding coincides with what she has been told, the listener selects a specific action. A third work that incorporates an endogenous and costly information acquisition mechanism is Kartik, Lee, and Suen (2017), where biased senders can acquire costly information and try to persuade a decision-maker to take a particular action. The main finding is that more senders do not necessarily translate into more benefit for the decision-maker, contrary to what one might think. A free-riding problem arises: a sender can benefit from other senders' efforts of information acquisition. So, a sender might put less effort into acquiring information, reducing the total amount of information that the decision-maker receives. Kartik et al. (2017) argue that the sender's linear preferences mainly explain this result over the decision-maker beliefs about the state of the world.

This thesis is also related to voting literature. Voting literature is vast. This branch usually focuses on voters' information aggregation and decision-making process; there is usually no information provider. In particular, how available information affects the decision-making process and the impact on voters' welfare. For example, Levy and Razin (2015) study the role of information in voting processes and how voters aggregate information to take a specific action and neglect the correlation between information sources. Gershkov and Szentes (2009) study how voters aggregate information when they can privately acquire privileged information with a cost. Ding and Pivato (2021) focus on information aggregation when voters have homogenous preferences but heterogeneous beliefs. In particular, each voter has hard facts, but they face a disclosing cost. Voters want to make the best choice. Nonetheless, although voters' private information might not be completely correct, some voters try to persuade neutral voters. Ding and Pivato (2021) explain that this might be due to voters' prior information is the best guess they have about what action to take.

When incorporating an information provider or sender, the addressed questions are similar, and special attention is paid to how communication occurs between voters and a sender. In particular, Kartik and van Weelden (2019) analyze how cheap talk (messages do not have specific meaning) can influence voters' beliefs and alter electoral outcomes. Electoral manipulation usually can occur via reputation. Schnakenberg (2015) consider a cheap talk information environment too. An informed expert has information about a relevant state of the world that is unknown to voters. In this environment, the expert can manipulate voters' decision-making process and, particularly, in a way that can reduce voter's welfare. Schnakenberg (2015) highlights that communication between an expert and a group of decision-makers might not always be mutually beneficial.

Alonso and Câmara (2016) discuss how the transmission of information takes place between a committee (receivers) and an adviser (sender) when Bayesian persuasion is the main communication mechanism. Additionally, they also pay special attention to voters' welfare implications and their relation with the voting rule, as in this thesis. Among their principal findings, super-majority rules are preferred over simple-majority by voters. Higher voting rules incentivize the adviser to design more informative experiments. Nevertheless, if voters choose a "too high" voting rule, which results in selecting a pivotal voter who is too hard to persuade, in that case, the adviser might be unable to provide convincing experiments, and the committee would reject the proposal most of the time. So, a middle point is more desirable.

Caillaud and Tirole (2007) do a similar analysis but incorporate verifiable information as the strategic communication mechanism and focus on cascade persuasion. An adviser can provide verifiable information to a committee. However, in contrast to other papers, this information is not public. Instead, the adviser can transmit this information to key agents inside the committee. If the sender persuades these agents, other agents will be convinced by the adviser as well. Caillaud and Tirole (2007) pay special attention to how the committee composition facilitates persuasion. Similarly, Jackson and Tan (2013) study how a finite group of biased advisers (senders) transmit verifiable information to a group of voters. Their findings show that voters' structure and the voting rule will determine how advisers reveal information. In particular, it will depend on the pivotal voter preferences. Additionally, Titova (2021) focuses on the communication of verifiable information from an informed sender to a group of voters. However, the sender does not publicly share this information; he instead targets information to particular groups of voters. In contrast to the current work, this information is exogenous and with no cost; the sender has state independent preferences. The sender can communicate private messages to each voter.

1.2 Thesis structure

The remaining chapters of the thesis are the following. Chapter 2 describes the framework of the model. Chapter 3 develops a simple six-voter example and generalizes the obtained so derived insights for a set of n voters, analyses the adviser's optimal information acquisition, and explores welfare implications. Finally, chapter 4 discusses and compares these results with other models' findings that involve other strategic communication mechanisms and concludes with the final remarks.

Chapter 2

Model

2.1 Framework

First of all, let us describe the framework of the model briefly. As mentioned earlier, a group of voters must decide whether to approve or reject a policy proposal whose convenience depends on an unknown state of the world. So, voters rely on an unbiased adviser to provide information. Before voters take any decision, the adviser conducts a research that can provide information about the state of the world, which can be unsuccessful. If the adviser succeeds in his research, he can decide whether to disclose or conceal it; if he is not successful, he remains silent. Then, depending on what the adviser decides to transmit (or not), voters update their beliefs about the state of the world and make a decision. If there are enough votes in favor of the proposal, it is implemented; otherwise, the committee rejects it.

Now, with more detail, the model can be described as follows. Players are fully rational Bayesian agents. There is an adviser (he), $i = 0$, and a finite set of voters $i \in N = \{1, ..., n\}$ (we refer to each one as she). Each of the voters must cast a vote $x_i \in \{Y, N\}$ either in favor ($x_i = Y$) or against ($x_i = N$) a certain proposal.

Voting. The payoff of each voter i depends on the final decision implemented by the adviser $a \in \{\underline{a}, \overline{a}\}$ and on an unknown state of the world $\omega \in R$. Here, $a = \underline{a}$ is interpreted as not implementing the proposal and $a = \overline{a}$ as implementing the proposal. Consider that the proposal is implemented if the number of voters that vote for it is at least than k, that is, $|i \in N|x_i = Y\}| \geq k$, where $k \in \{1, ..., n\}$. In particular $k = 1$ gives us a dictatorship voting rule, $k = n$ describes an unanimity voting rule, and $k = \frac{n}{2} + 1$ gives us a simple majority rule.

Preferences. Each player $i \in N$ has the same payoff function $u(a, w)$, which is specified as

$$u_i(\underline{a}, \omega) = \left\{ \begin{array}{c} 0 \text{ if } \omega < 0 \\ -L \text{ if } \omega \geq 0 \end{array} \right\} \text{ and } u_i(\overline{a}, \omega) = \left\{ \begin{array}{c} -L \text{ if } \omega < 0 \\ 0 \text{ if } \omega \geq 0 \end{array} \right\}$$

where $L > 0$. Therefore, each player prefers action $\overline{a}$ to be implemented whenever $w \geq 0$ and action $\underline{a}$ to be implemented whenever $\omega \leq 0$. Preferences are common across players.

Information Structure. The players (commonly) know that the state of the world is distributed according to $\omega \sim N(\mu_i, \sigma_0^2)$, where $\mu_0 = 0$ represents the adviser's beliefs about the mean of the state of the world, $\mu_i \neq 0$ for each $i \in N$, with $\mu_i \neq \mu_j$ for each pair $i, j \in N$ voters. Notice that voters' beliefs are normalize with respect to the belief of the adviser. As in Che and Kartik (2009), there is no conflict of interests in the players' preferences, though they have different priors about the state of the world. This will make them disagree on the suitability of the proposal. Using the typical Bayesian games terminology, the adviser has a continuum of possible types $\omega \in R$. Nevertheless, from the preference specification, we observe that his set of payoff-relevant types can be set as either $\omega < 0$ or $w \geq 0$.

Voters structure. Let n be even and Let $N^+ = \{1, ..., n/2\} \subset N$ and $N^- = \{n/2 + 1, ..., n\} \subset N$. Each $i \in N^+$ has $\mu_i > 0$ and each $i \in N^-$ has $\mu_i < 0$, with and $\mu_i > \mu_{i-1}$ for all i. That is, half of voters believe that the state of the world has a positive mean and hence they would vote to approve the implementation of the proposal while the other half has negative beliefs and would vote against the proposal if they had no information at all.

Information Acquisition. The adviser can costly acquire additional information about ω, a signal s. As in Che and Kartik (2009), the adviser chooses the probability $p \in (0; \bar{p}]$, for $\bar{p} < 1$, that his investigation be successful. Then, with such an (endogenously chosen) probability p, the adviser obtains a signal $s \sim N(\omega, \mu_i^2)$, where $\sigma_0^2 > 0$. With probability $1-p$, the investigation is unsuccessful and he obtains no signal, denoted as $\emptyset$. The information acquisition cost is captured by a cost function $c : [0; \bar{p}] \to \mathbb{R}_+$, where $c(p)$ is smooth, increasing, and convex. Also, consider $c(p = 0) = 0$, and $\lim_{p \to \bar{p}} c(p) = +\infty$. Standard results on normal distributions lead to that, from the perspective of player i, the relevant state of the world ω and the signal s that the adviser can obtain are jointly distributed as

$$\begin{pmatrix} \omega \\ s \end{pmatrix} \sim N \left(\begin{pmatrix} \mu_i \\ \mu_i \end{pmatrix}, \begin{pmatrix} \sigma_0^2 & \sigma_0^2 \\ \sigma_0^2 & \sigma_0^2 + \sigma_1^2 \end{pmatrix} \right)$$

Therefore, from player i's viewpoint, the marginal distribution of signals s is given by $s \sim N(\mu_i, \sigma_0^2 + \sigma_1^2)$. Accordingly, let $\gamma(s; \mu_i)$ be the density function of a normal distribution with mean μ_i and variance $\sigma_0^2 + \sigma_1^2$.

Information Disclosure. After privately observing the outcome of his investigation, the adviser decides whether to disclose the signal, provided that he has obtained it, or to withhold any information, even if he has obtained the signal. The adviser can not transmit this signal privately to particular voters, once disclosed it is public information. Information disclosure is verifiable (based on hard facts) so the adviser can only withhold information but he cannot falsify or manipulate the obtained signal. Neither information acquisition nor information disclosure are contractible. Thus the voters cannot offer monetary incentives to affect the adviser strategy on information acquisition and disclosure. The incentives to the adviser to comply with the voters' preferences follow thus in equilibrium, due to that the voting decisions x_i ultimately affect the adviser's utility.

Optimal Actions (Conditional on Receiving a Signal). Suppose that the adviser is successful in obtaining signal s, and, furthermore, he chooses to disclose it publicly to the voters. Results on normal distriburions led to that, conditional on receiving a signal s, a voter whose prior expectation of the state is μ_i considers that

$$\omega | s \sim N(\rho s + (1-\rho)\mu_i, \tilde{\sigma}^2),$$

where $\rho = \frac{\sigma_0^2}{\sigma_0^2+\sigma_1^2}$ and $\tilde{\sigma}^2 = \frac{\sigma_0^2\sigma_1^2}{\sigma_0^2+\sigma_1^2}$. Therefore the preferred action of player i, conditional on observing a signal s,

$$\alpha_i(s) = \begin{Bmatrix} \underline{a} \text{ if } s < -[(1-\rho)/\rho]\mu_i \\ \overline{a} \text{ if } s \geq -[(1-\rho)/\rho]\mu_i \end{Bmatrix} \tag{2.1}$$

Accordingly, we can define the *interim* bias of the adviser relative to voter i as $b(\mu_i) \equiv [(1-\rho)/\rho]\mu_i$.

Equilibrium Information Disclosure. First note that, if the adviser observes the signal s, then it is optimal for him to withhold it to voter i if $s \in R_i$, where R_i is a closed real interval specified as $R_i \equiv [b(\mu_i), 0]$ for $\mu_i < 0$ and $R_i \equiv [0, b(\mu_i)]$ for $\mu_i > 0$. Now, consider an arbitrary interval $S \subset R$ of signals that the adviser may withhold to a voter i. Then, if voter i receives the message $\emptyset$ from the adviser, she interprets this in a Bayesian way. In particular, conditional on receiving message $\emptyset$ voter i knows that with probability p the adviser actually obtained a certain signal $s \in S$, and with probability $1-p$ the adviser research efforts were indeed unsuccessful, $s = \emptyset$. Therefore, voter i will determine her optimal vote according to the expected signal

$$E_{\gamma(\cdot;\mu_i)}[s | s \in S] = \int_s s\gamma(s;\mu_i)\, ds \tag{2.2}$$

with probability

$$q(S;\mu_i) \equiv \frac{p\displaystyle\int_s \gamma(s;\mu_i)\, ds}{p\displaystyle\int_s s\gamma(s;\mu_i)\, ds + (1-p)}, \tag{2.3}$$

and according to her initial prior μ_i, with probability

$$1 - q(S; \mu_i) \equiv \frac{1-p}{p \displaystyle\int_s s\gamma(s;\mu_i)\, ds + (1-p)}. \quad (2.4)$$

Therefore, for the a research effort p chosen by the adviser, the optimal vote

$$\alpha_{i,\emptyset}(S,p) = \begin{Bmatrix} x_{i,\emptyset} = N \text{ if } \displaystyle\int_s s\gamma(s;\mu_i)\, ds < b(\mu_i) \\ x_{i,\emptyset} = Y \text{ if } \displaystyle\int_s s\gamma(s;\mu_i)\, ds \geq b(\mu_i) \end{Bmatrix} \quad (2.5)$$

with probability $q(S; \mu_i)$, and

$$\alpha_{i,\emptyset}(S,p) = \begin{Bmatrix} x_{i,\emptyset} = N \text{ if } \mu_i < 0 \\ x_{i,\emptyset} = Y \text{ if } \geq \mu_i \end{Bmatrix}, \quad (2.6)$$

with probability $1 - q(S; \mu_i)$. Therefore, starting from an investigation effort p chosen by the adviser, the expected optimal vote of voter i, conditional on an interval of signals S that the adviser may withhold and on receiving message $\emptyset$, is given by

$$E_{q(S;\mu_i)}[\alpha_{i,\emptyset}(S,p)] =$$

$$q(S;\mu_i) \begin{Bmatrix} x_{i,\emptyset} = N \text{ if } \displaystyle\int_S s\gamma(s;\mu_i)\, ds < b(\mu_i) \\ x_{i,\emptyset} = Y \text{ if } \displaystyle\int_S s\gamma(s;\mu_i)\, ds \geq b(\mu_i) \end{Bmatrix} + [1 - q(S;\mu_i)] \begin{Bmatrix} x_{i,\emptyset} = N \text{ if } \mu_i < 0 \\ x_{i,\emptyset} = Y \text{ if } \geq \mu_i \end{Bmatrix}. \quad (2.7)$$

Equilibrium Information Acquisition. All players have only two possible outcomes: a favorable outcome, that is, the action taken by the committee coincides with the player's preferences. For example, given a voting rule k, there are enough votes to approve the proposal, and some voter i believes that the proposal should be approved and hence votes to approve it; or an unfavorable outcome, the other way around. The adviser can receive a favorable or unfavorable signal in the information acquisition process by considering the possible outcomes. So, the adviser will select an effort level p that maximizes the probability of obtaining a favorable signal, or equivalently the effort level p that minimizes the probability of getting an unfavorable signal for a given voting rule.

Timing. The stages of the model are the following.

1. Nature selects ω which is unknown to all players.

2. The adviser selects the effort level p that he exerts.

3. Nature randomly draws a signal s which only the adviser observes.

4. If the adviser observes $s \neq \emptyset$, he decides whether to disclose or not this signal. If he decides to disclose it, signal s is observed by all voters; if he decides to conceal, he remains silent, that is voters observe $s = \emptyset$. If signal $s = \emptyset$, the adviser can only remain silent.

5. Voters update their priors as derived above and then decide whether to vote in favor or against the proposal according to their preferences.

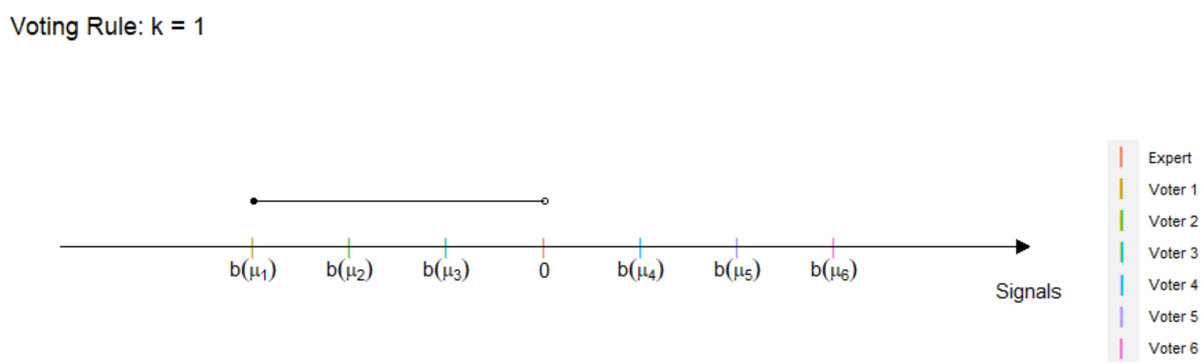
6. Each player learns the electoral outcome and receives her payoff.

Chapter 3

Equilibrium Analisys

3.1 A six-voter example

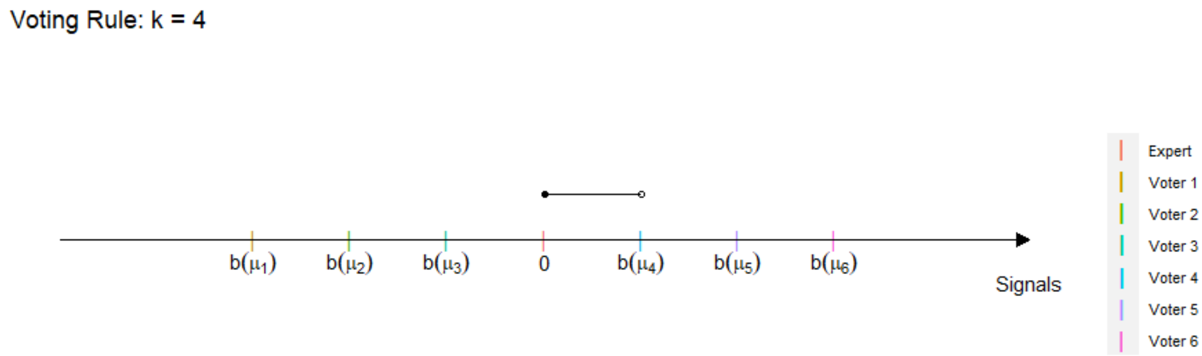
Figures 3.1: Six voters and voting rule k = 1.



Source: Own elaboration.

Let us start with a simple six-voter example, $N = \{1, 2, 3, 4, 5, 6\}$. In particular, voters have the following prior beliefs about the mean of the state of the world: $\mu_1 > \mu_2 > \mu_3 > 0 > \mu_4 > \mu_5 > \mu_6$. Notice that if the adviser could not acquire any information or selects $p = 0$, half of the voters believe that the state of the world has a negative value and, in consequence, would like to reject the proposal's implementation. In contrast, the other half believe that the state of the

Figures 3.2: Six voters and voting rule k $= 4$.



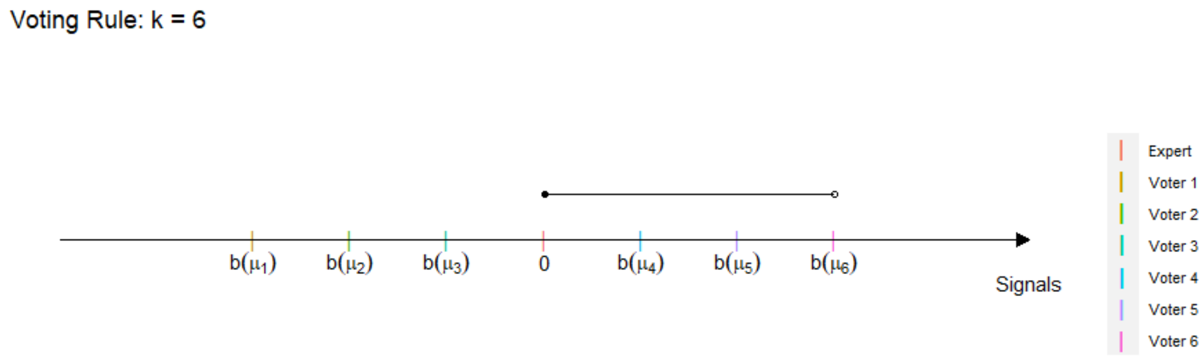
Source: Own elaboration.

world has a positive value and, hence, would like to approve the proposal's implementation. The adviser would like to see the proposal's implementation since his prior belief about the mean of the state of the world is nonnegative, $\mu_0 = 0$.

Suppose that the adviser selects an arbitrary effort level $p \in (0, \overline{p}]$. With probability p he obtains a signal s, and this signal is available to all players, or the adviser indistinctly decides to disclose it. Recall equation 2.1; we can represent each voter i course of action as a threshold point $b(\mu_i)$ that indicates what decision they make conditional on observing some signal s. Notice that, conditional on observing a particular signal, voters might prefer to take different actions despite the sign of signal s. For example, for a positive signal, voters might infer that the state of the world is indeed positive, $b(\mu_i) < s$, and, therefore, they should approve the proposal, $\alpha_i = \overline{a}$. However, for this same signal, it might be the case that other voters think the opposite. The signal is positive but not large enough to convince them that the state of the world is positive –good news are not *good enough*–, $s < b(\mu_i)$, so they prefer to reject the proposal, $\alpha_i = \underline{a}$. As we will further see, this influences the adviser's decision to disclose or not information.

Now, consider that the adviser succeeds in his research, and signal s is only available to him. Which signals does the adviser decide to disclose or withhold? First, for this example, consider a voting rule $k = 1$. Figure 3.1 depicts this scenario. To implement the proposal, it

Figures 3.3: Six voters and voting rule k $= 6$.



Source: Own elaboration.

is enough that just one voter cast her vote in favor of its approval for this voting rule. Notice that if the adviser observed a signal below voter $i = 1$'s threshold, that is, $s < b(\mu_1)$, all voters would infer that the state of the world has a negative value and reject the proposal, $\alpha_i = \underline{a}$ for all $i \in N$. This result would be in line with the adviser's preferences conditional on observing such a signal. So, to obtain the implementation of the proposal, the adviser optimally decides to disclose it. In contrast, if the adviser received a signal inside the interval $[b(\mu_1), 0)$, at least voter $i = 1$ would cast her vote in favor of the proposal. Given the voting rule $k = 1$, her vote would be enough to implement it. However, the adviser would like to avoid this outcome since $s < 0$. So, the adviser prefers to withhold such a signal. Finally, if the adviser observed a nonnegative signal, he prefers to approve the proposal, and at least voters $i = \{1, 2, 3\}$ would cast their vote to approve it. Given the voting rule, this would be enough to approve the proposal, so the adviser has incentives to disclose such signals if observed. Therefore, the adviser would disclose all signals that are outside the set $[b(\mu_1), 0)$ or equivalently selects $S(\mu_i, k) = [b(\mu_1), 0)$ as the nondisclosure set for a voting rule $k = 1$. The adviser will hide all signals that, with certainty, lead to his less preferred outcome.

If the voting rule changes to, for example, $k = 4$, the adviser would hide signals in the same way but for a different nondisclosure set. Figure 3.2 illustrates this. Notice that the adviser will disclose all negative signals, conditional on observing such signals. For example, suppose that the adviser receives a signal inside $[b(\mu_1), 0)$. For this signal, with certainty, at least voter $i = \{1\}$ would cast her vote in favor of the proposal. However, even if the signal is not *negative enough* to make voters 2 and 3 to infer that the state of the world has a negative value, and hence vote in favor of the proposal too, there would not be enough votes to approve the proposal. In consequence, the committee will not implement the proposal. This outcome is in line with the adviser's preferences so that he will disclose all those signals. If the adviser received a signal inside $[0, b(\mu_4))$, voters $i = \{1, 2, 3\}$ would cast their vote in favor of the proposal. Conditional on observing such a signal, the adviser wants the proposal to be approved by the committee. Nevertheless, there would not be enough votes to implement it; an additional vote is required. Along with voters $i = \{1, 2, 3\}$, at least voter $i = 4$ must cast her vote in favor of the proposal to implement it. So, for $s \in [0, b(\mu_4))$ the proposal will be rejected. So, the best thing the adviser can do is to withhold such a signal and hope to confuse voter 4, as specified in equation 2.7. For a signal $s \geq b(\mu_4)$, voters $i = \{1, 2, 3, 4\}$ infer that the state of the world has a positive value and cast their vote to approve the proposal. It does not matter if voters $i = \{5, 6\}$ vote against the proposal, there are at least four votes to achieve the majority rule. Again, this aligns with the adviser's preferred action; hence, he will disclose all such signals. Consequently, the adviser would hide all signals that voter 4 would cast her vote to reject the proposal. So, the nondisclosure set would be $S(\mu_i, k) = [0, b(\mu_4))$ for a voting rule $k = 4$.

Finally, consider a voting rule $k = 6$, that is, unanimity is required, as in figure 3.3. As with the previous voting rule, if the adviser observed a negative signal, he will disclose this signal. Although for some negative signals, voters $i = \{1, 2, 3\}$ would like to vote in favor of the proposal, there are not enough votes to reach unanimity. Voters $i = \{4, 5, 6\}$ will always cast their vote against the proposal. So the proposal is not implemented. If, in contrast, a signal lies between the interval $s \in [0, b(\mu_6))$, the adviser would like to implement the proposal. There will not be enough votes because voter $i = 6$ will always cast her vote against the proposal. The adviser will try to avoid the immediate rejection of the proposal by withholding all such signals and try to persuade voters 6. Finally, if the adviser observes a signal above $b(\mu_6)$, he will disclose all such signals because voters favor the proposal. The optimal nondisclosure set would be $S(\mu_i, k) = [0, b(\mu_6))$ for a voting rule $k = 6$.

3.2 Optimal Nondisclosure Set

From the previous example, we can notice that for each voting rule, there is a key or pivotal voter who, if all signals that the adviser received were public information, would be the one that determines the committee decision. For a voting rule $k = 1$, voter $i = 1$ is the pivotal voter, for $k = 4$, voter $i = 4$ and for unanimity, voter $i = 6$. Conditional on observing certain signal s, the pivotal voter will allow or not the committee to achieve the minimum required votes to approve the proposal. Let μ_k denote the pivotal voter of a given voting rule k. Also, notice that for a given voting rule k, if $b(\mu_k) < s$, the pivotal voter cast her vote in favor of the proposal, all voters with $\mu_i > \mu_k$ cast their vote in favor of the proposal as well. When $s < b(\mu_k)$, the pivotal voter wants to reject the proposal, all voters with $\mu_i < \mu_k$ for a given voting rule k want to reject the proposal too. Most importantly, who is the pivotal voter will influence how the adviser strategically withholds signals. Specifically, the adviser withholds signals that with probability 1 the pivotal voter takes a different action that he thinks the committee should take. This intuition leads us to the next proposition.

Proposition 1. *For any voting rule $k \in N$, the adviser optimally selects a nondisclosure set $S(\mu_k, k)$ as follows:*

- *for $k \in \{1, ..., \frac{n}{2}\}$, $S(\mu_k, k) = [b(\mu_k), 0)$;*
- *for $k \in \{\frac{n}{2}, ..., n\}$, $S(\mu_k, k) = [0, b(\mu_k))$.*

The adviser strategically discloses signals that allow him to maximize his utility in the interim stage. Signal disclosure occurs whenever the signal leads the committee to take the same action that the adviser prefers. Otherwise, the adviser withholds signals, particularly with the intention to try to persuade the pivotal voter to take the action the adviser prefers. Also, notice that when the voting rule requires less than $\frac{n}{2}$ and as the voting rule is more demanding, the adviser will withhold fewer signals; however, as it is higher than $\frac{n}{2}$ and it becomes more demanding, the adviser withholds more signals. For example, in the previous example, the adviser conceals more signals when the voting rule is $k = 6$ than when it is $k = 1$, $b(\mu_4) < b(\mu_4)$ and hence $S(4, b(\mu_4)) \subset S(6, b(\mu_6))$. Similarly, the adviser would conceal fewer signals for a voting rule $k = 2$ or $k = 3$ than with a voting rule $k = 1$.

3.3 Optimal Information Acquisition

With the optimal nondisclosure set defined, we can derive the optimal effort level that the adviser selects in the ex-ante stage of the model. First, notice that according to each voting rule k, the adviser can receive two types of signals. On the one hand, there are favorable signals, that is, all those signals $s \notin S(\mu_k, k)$ for a given voting rule k. If those signals were observed and disclosed, they would lead to the adviser's preferred outcome with a probability 1. On the other hand, there are unfavorable signals, that is, all those signals $s \in S(\mu_k, k)$. If those signals were observed and disclosed, they would lead to the least preferred outcome with a probability 1.

Second, voters are only aware of the effort level p that the adviser selects in the ex-ante stage, but not whether this effort was successful, $s \neq \emptyset$ with probability p, or not, $s = \emptyset$ with probability $1 - p$. So, voters will try to infer the actual probability that the adviser succeed in the information acquisition process. That is, the probability that he is telling the truth or lying by omission, whether he is an uninformed or informed adviser. Recall equation 2.7 from the previous chapter; voters will take an action randomizing between two criteria: if voter i thinks the adviser is telling the truth, she will use her prior beliefs about the state of the world ω to take any action; if voter i thinks that the adviser is withholding information, she will estimate the expected value of the signal inside the nondisclosure set and use it to infer the actual value of ω.

In particular, the adviser will pay attention to what the pivotal voter does under nondisclosure. For a given voting rule k, let

$$\phi(S(\mu_k,k),k) =$$

$$q(S(\mu_k,k);\mu_k)\begin{Bmatrix} x_{k,\emptyset}=N \text{ if } \int_S s\gamma(s;\mu_k)\,ds < b(\mu_k) \\ x_{k,\emptyset}=Y \text{ if } \int_S s\gamma(s;\mu_k)\,ds \geq b(\mu_i) \end{Bmatrix} + [1-q(S;\mu_k)]\begin{Bmatrix} x_{k,\emptyset}=N \text{ if } \mu_k < 0 \\ x_{k,\emptyset}=Y \text{ if } \geq \mu_k \end{Bmatrix}$$

be the probability that the pivotal voter approve the proposal under nondisclosure. By taking into account all of this, the adviser's expected utility in the ex-ante stage describe in the next proposition.[1]

Proposition 2. *For a voting rule $k \in N$, the adviser's expected utility for an effort level $p \in (0,\overline{p}]$ is*

- *for $k \leq \frac{n}{2}$*

$$U(p|S,k) = -L\phi_k(S(\mu_k,k))\left[1 - p\int_{s\notin S(\mu_k,k)} \gamma(s;0)\,ds\right] - c(p);$$

- *for a voting rule $k > \frac{n}{2}$*

$$U(p|S,k) = -L[1-\phi_k(S(\mu_k,k))]\left[1 - p\int_{s\notin S(\mu_k,k)} \gamma(s;0)\,ds\right] - c(p).$$

In the ex-ante stage, the adviser will select an effort that allows him to minimize the probability of obtaining an unfavorable signal.

Notice that the advisor's expected utility function is concave in p. By obtaining the first-order conditions for both cases, it allows us the optimal effort level p that maximizes the expected

[1] For a voting rule $k \leq \frac{n}{2}$, the adviser only will hide signals that indicate him not to implement the proposal but that k-voters will vote for approval. For a voting rule $k > \frac{n}{2}$, the opposite occures, the adviser will hide signals that the indicate him to implement the proposal but that less than k-voters will vote in favor.

utility. We obtain the next characterization

$$L\phi_k(k)\left(\int_{s\notin S(\mu_k,k)}\gamma(s;0)\,ds\right)=c'(p^*)$$

and

$$L(1-\phi_k(k))\left(\int_{s\notin S(\mu_k,k)}\gamma(s;0)\,ds\right)=c'(p^*).$$

Now, let us take a step back into how voters decide whether to approve or reject the proposal under nondisclosure. In particular, let us focus on the pivotal voter's action under nondisclosure. Under nondisclosure, voters do not know if the adviser is informed or uninformed. Equivalently voters do not know if the adviser tells the truth about the information acquisition or is lying by omission. As in equation 2.7, we can see that each voter i with probability $1-q(S;\mu_i)$ thinks that the adviser is telling the truth or is an uninformed adviser, so each voter uses their prior beliefs.

First consider a voting rule $k\leq\frac{n}{2}$. In this case, the pivotal voter has a positive opinion of the state of the world, that is, $\mu_k>0$, so with probability $1-q(S;\mu_k)$ he will vote to approve the proposal, as well as all other voters with $\mu_i>0$. With probability $q(S;\mu_i)$, voters think that the adviser is lying and, therefore, each of them estimates the expected value of the signal inside the nondisclosure set. The expected value of this signal will be inside the nondisclosure set; that is, it will be somewhere $[b(\mu_i),0)$ for voting rules $k\leq\frac{n}{2}$. In consequence, $b(\mu_k)<\int_{s\in S(\mu_k,k)}s\gamma(s;\mu_k)\,ds<0$ and, in particular, for the pivotal voter $b(\mu_k)<\int_{s\in S(\mu_k,k)}s\gamma(s;\mu_k)\,ds$. So, the pivotal voter will vote in favor of the proposal with probability $q(S;\mu_k)$. The pivotal voter will approve the proposal when the adviser claims that he was unsuccessful in his research. The pivotal voter's action under nondisclosure makes sense since the adviser only hides signals that, if disclosed, the pivotal voter will approve the proposal when he wants its rejection. This outcome is in line with verifiable information literature. There are two implications for this model. First, since the pivotal voter votes in favor of the proposal with probability one when the adviser is uninformed, under nondisclosure, there are enough votes to approve the proposal, that is, $\phi_k = 1$ for $k \leq \frac{n}{2}$. Second, the adviser will be indifferent to disclose or not any unfavorable signal s if he had obtained any. However, now the adviser has stronger incentives to obtain a favorable signal.

The adviser's ex-ante utility will be for a voting rule $k > \frac{n}{2}$ is

$$U(p|S,k) = -L\left[1 - p\int_{s \notin S(\mu_k,k)} \gamma(s;0)\,ds\right] - c(p). \tag{3.1}$$

By deriving the first order conditions the optimal effort level will be

$$L\left[\int_{s \notin S(\mu_k,k)} \gamma(s;0)\,ds\right] = c'(p^*). \tag{3.2}$$

For a voting rule $k > \frac{n}{2}$, we can arrive at a similar conclusion: under nondisclosure, the pivotal voter will reject the proposal with a probability of 1, so there will not be enough votes to implement it according to the voting rule k, even though some voters will randomize between approving or rejecting and others will approve it with probability 1. Thus, the probability of approving the proposal under nondisclosure will be $\phi_k = 0$ for a voting rule $k > \frac{n}{2}$. The adviser's ex-ante utility will be for a voting rule $k > \frac{n}{2}$ is

$$U(p|S,k) = -L\left[1 - p\int_{s \notin S(\mu_k,k)} \gamma(s;0)\,ds\right] - c(p). \tag{3.3}$$

By deriving the first-order conditions, the optimal effort level will be

$$L\left[\int_{s \notin S(\mu_k,k)} \gamma(s;0)\,ds\right] = c'(p^*). \tag{3.4}$$

By taking this into account, the analysis simplifies. Notice that with this simplification, the probability of obtaining an unfavorable signal now is higher; so, by being skeptical, voters can incentivize the adviser has more incentives to acquire more information.

3.4 Comparative Statistics

With this characterization of the equilibrium, we can obtain some comparative statistics. The most straightforward insight is that when the loss $-L$ is larger, the adviser will exert a higher effort level p^*. For any voting rule $k \in \{1, ..., N\}$, notice that as the loss L rises, the marginal cost $c'(p)$ rises. Since the effort cost $c(p)$ is convex, a higher $c'(p)$ implies a higher effort level p. So, by the implicit function theorem

$$\frac{\partial p^*}{\partial L} > 0. \tag{3.5}$$

A higher loss implies that the gain the adviser can obtain from acquiring a favorable signal is larger, so he sets more effort into obtaining a signal that allows him to persuade the committee.

Changes in the voting rule can have two effects on the optimal effort level p^*. First, recall equation 3.2 and proposition 1; for a voting rule $k \leq \frac{n}{2}$, the adviser discloses more signals. So, probability $\int_{s \notin S(\mu_k, k)} \gamma(s; 0)\, ds$ is larger and the marginal cost $c'(p)$ will become larger too. Since the effort cost $c(p)$ is convex, a higher $c'(p)$ implies a higher effort level p. So, for a voting rule $k \leq \frac{n}{2}$ and by the implicit function theorem,

$$\frac{\partial p^*}{\partial k} > 0. \tag{3.6}$$

In this case, as the voting rule becomes more strict, the pivotal voter becomes a voter who has more similar opinions to the adviser's opinion. Hence, the adviser has more probability of persuading the committee. Recall from the six-voter example, when the voting rule $k = 1$ the pivotal voter is voter 1. If the voting rule changes to, for example, $k = 2$, voter 2 becomes the pivotal voter. Voter's 2 beliefs about the state of the world are closer to the adviser's opinions, $b(\mu_1) < b(\mu_2) < 0$. So, the adviser will disclose more signals, or equivalently the nondisclosure set is smaller. In consequence, the probability of obtaining a signal outside the nondisclosure set ($\int_{s \notin S(\mu_k, k)} \gamma(s; 0)\, ds$) increases and this incentivizes the adviser to exert a higher effort level p^*.

Second, recall from equation 3.4 and proposition 1. For a voting rule $k > \frac{n}{2}$, as the voting rule becomes more strict, the adviser conceals more signals, which leads to a decrease of probability $\left(\int_{s \notin S(\mu_k, k)} \gamma(s; 0)\, ds\right)$. This implies that the marginal cost $c'(p)$ decreases as well and, since the effort cost $c(p)$ is a convex function, this implies a lower effort level p. So, for a voting rule $k > \frac{n}{2}$ by the implicit function theorem,

$$\frac{\partial p^*}{\partial k} < 0. \tag{3.7}$$

In contrast with the previous case, the pivotal voter becomes a voter who differs more and more in his opinions with respect to the adviser. Recall from the six-voter example when the voting rule is $k = 4$ and consider it changes to $k = 6$. First, the pivotal voter is voter 4 and then is voter 6. Now the pivotal voter is harder to persuade, notably harder to persuade to approve the proposal. So the adviser will withhold more signals, the probability of persuading the committee is smaller ($\int_{s \notin S(\mu_k, k)} \gamma(s; 0)\, ds$) and, hence, the probability of obtaining a favorable signal decreases. Thus, the adviser puts less effort.

3.5 Welfare Analysis

Regarding welfare, we can answer the question of what voting rules do players prefer. First, what voting rule does the adviser prefer in the ex-ante stage? First, notice that as the voting rule k is closer to $\frac{n}{2}$ or to $\frac{n}{2} + 1$, the probability of not obtaining favorable signals diminishes; in consequence, the probability of obtaining a favorable signal increases. At the same time, this incentivizes the adviser to exert more effort –for a voting rule $k \leq \frac{n}{2}$ as it becomes more strict, the adviser selects a higher effort level p^* while for a voting rule $k \leq \frac{n}{2}$ as it becomes less strict, the adviser selects a higher effort level p^*. However, as the adviser puts more effort into his research, he faces a higher cost too. So, as long as the marginal cost does not strictly exceed the marginal benefit, the adviser finds it beneficial to select a voting rule k that makes the voter with the closest opinions to his opinions in the ex-ante stage of the model. These intuitions lead us to the next proposition.

Proposition 3. *The optimal voting rule k^* that the adviser selects is a voting rule $k^* \in \{\frac{n}{2}, \frac{n}{2}+1\}$ such that* $b(\mu_{k^*}) = \min\{|b(\mu_{\frac{n}{2}})|, |b(\mu_{\frac{n}{2}+1})|\}$.

From Proposition 3 we can see that the adviser wants a voting rule that increases the probability of obtaining favorable signals, that is, signals that allow him to persuade the committee. To accomplish this objective, he needs to increase probability of obtaining a signal, p^*, and probability that this signal is not inside the nondisclosure set, $\int_{S(\mu_k,k)} \gamma(s;0)\,ds$. So, the optimal voting rule k^* must minimize the size of the nondisclosure set $S(\mu_k, k)$ to maximize both probabilities and this is accomplish with the voting rule that indirectly selects a voter whose opinions are closer to the adviser's opinions, that is, $b(\mu_{k^*}) = \min\{|b(\mu_{\frac{n}{2}})|, |b(\mu_{\frac{n}{2}+1})|\}$.

Now, which voting rule do voters as a committee prefer? Let us suppose that a social planner –a player different from all voters, and the adviser– has to select a voting rule k that maximizes the sum of all voters' expected utility in the ex-ante stage of the model. With this objective in mind, the social planner would choose a voting rule k that maximizes the probability that a majority of voters obtain payoff of 0, that is, at least $\frac{n}{2}+1$ voters, with an ex-ante perspective. Equivalently, set a voting rule that minimizes the probability that less than $\frac{n}{2}+1$ voters obtain payoff of 0, that is, $P\left(|i \in N|u_i = 0| < \frac{n}{2}+1\right)$.

Proposition 4. *For any voting rule $k \in N$, the probability that less than $\frac{n}{2}+1$ voters obtain payoff of 0 is*

- *for* $k \in \{1, ..., \frac{n}{2}\}$
$$P\left(|i \in N|u_i = 0| < \frac{n}{2}+1\right) =$$
$$-\frac{1}{2}p^*\left[\int_{s\notin S(\mu_k,k)} \gamma(s;0)\,ds - \int_0^{b(\mu_{\frac{n}{2}+1})} \gamma(s;0)\,ds\right] + \frac{1}{2};$$

- *for* $k \in \{\frac{n}{2}+1, ..., n\}$,
$$P\left(|i \in N|u_i = 0| < \frac{n}{2}+1\right) =$$

$$-\frac{1}{2}p^* \left[\int_{s \notin S(\mu_k, k)} \gamma(s; 0)\, ds - \int_{b(\mu_{\frac{n}{2}})}^{0} \gamma(s; 0)\, ds \right] + \frac{1}{2}.$$

The optimal voting rule k^* that a social planner selects to maximize the committee welfare, that is, a k^* that minimizes $P\left(|i \in N | u_i = 0| < \frac{n}{2} + 1\right)$, is $k_s^* \in \{\frac{n}{2}, \frac{n}{2} + 1\}$ such that $b(\mu_{k^*}) =$ $\min\{|b(\mu_{\frac{n}{2}})|, |b(\mu_{\frac{n}{2}+1})|\}$.

Proposition 4 decomposes the probability that less than $\frac{n}{2} + 1$ voters obtain payoff of 0. Notice that this probability depends indirectly on the voting rule in two ways. First, it depends indirectly on the voting rule via the effort level p^* that the adviser sets in equilibrium. Recall the six-voter example: if the adviser claims that he obtained no signal, voters cast their vote according to equation 2.7. In such a scenario, only half of voters would receive payoff of 0 for either voting rule $k \leq \frac{n}{2}$ or $k < \frac{n}{2}$. So, the social planner would like to choose a voting rule that incentivizes the adviser to obtain some signal and allow voters to make an informed decision. Second, the probability that less than $\frac{n}{2} + 1$ voters obtain payoff of 0 depends indirectly on the voting rule through the probability that a signal s lies outside the nondisclosure set, $\int_{s \notin S(\mu_k, k)} \gamma(s; 0)\, ds$. The social planner not only wants voters to make an informed decision but also to allow the majority of voters to agree on the course of action to take. So, the social planner selects a voting rule that incentivizes the adviser to exert more effort and disclose more information, both adviser's incentives in the ex-ante and interim stages. Thus, the voting rule must be in line with the adviser's incentives.

Now, notice that the social planner prefers a voting rule that indirectly selects as the pivotal voter a voter i whose opinions are closer to the adviser's opinions. Although the probability of obtaining a signal for which at least $\frac{n}{2} + 1$ voters to obtain payoff of 0 is equal for both $k^* = \frac{n}{2}$ and $k^* = \frac{n}{2} + 1$ in the interim stage, the adviser exerts more effort with a voting rule such that $b(\mu_{k^*}) = \min\{|b(\mu_{\frac{n}{2}})|, |b(\mu_{\frac{n}{2}+1})|\}$.

Chapter 4

Conclusions

When information is too costly to obtain, decision-makers usually rely on better-informed advisers to acquire information through research. In some specific cases, an adviser and a group of decision-makers might share preferences but still differ in their opinions. Examples that illustrate this could be situations that involve common threats, like the current COVID-19 pandemic. To overcome a common threat is usually required to take collective actions. Moreover, in every decision, having information is vital to confront such a threat. In this scenario, even the most biased adviser might desire that decision-makers take the best course of action. Nonetheless, differences in opinions still arise due to differences in experiences, personal beliefs, or political views. Alternatively, judiciary processes can illustrate this framework too. For example, a group of judges can rely on a detective to provide evidence that proves the innocence or guilt of suspects.

In the framework of this dissertation, information is interpreted as hard facts. Nonetheless, even when evidence is undeniable, it might be hard to change someone individual's opinion if the information is not perfect. So, as we saw in the previous chapters, an adviser that can obtain hard facts might try to hide information that he thinks might not lead to the best choice. In such a case, decision-makers are skeptical whenever the adviser claims to be unsuccessful in his research. Che and Kartik (2009) identify this effect as the prejudicial effect. Particularly, when a decision only involves two actions, decision-makers can infer what an adviser might find in his research and make a decision. This skepticism can work as an incentive for the adviser to effort more.

Also, the institutional design of the decision-making process plays an important role. In this case, the voting rule that defines how a group of decision-makers or committee approves or rejects a proposal determines how hard it is for an adviser to persuade the committee. Thus, voting rules indirectly select a particular decision-maker as a pivotal voter who determines the committee decision. If this pivotal voter is one whose opinions are closer to the adviser's opinions, she is easier to persuade and, therefore, more accessible for the adviser to persuade the committee. Under an ex-ante perspective, this increases the chance that the adviser obtains helpful information according to his opinions. Although Alonso and Câmara (2016) consider a biased adviser and a different strategic communication framework, they find that these incentives drive how the adviser designs informative research.

Finally, if it is suitable for an adviser to obtain more information, it will be better for the decision-makers. Particularly, with a centrist or moderate adviser, the best voting rule for a group of decision-makers is a simple majority rule. With such a voting rule, the adviser has incentives to effort more and share his findings with the committee. The information he obtains and shares will allow most decision-makers to make an informed decision and agree on the best course of action.

Appendix A

Proofs of Propositions

Proof of Proposition 1. Take a given voting rule $k \in N$. Consider a voting rule $k \in \{1, ..., \frac{n}{2}\}$. Note then that $\mu_k > 0$ –and thus $b(\mu_k) < 0$– for the kth (pivotal) voter, given the considered arrangement of the voter's prior beliefs about the state of world. Given a signal $s < 0$ observed by the adviser, it follows that if any signal $s < b(\mu_k)$ is publicly observed, then a number less than k voters will vote $x_i = Y$. Even though the adviser prefers rejection for such signals, those voters are not sufficient to attain the approval outcome. By disclosing only those signals $s < b(\mu_k)$, the interim expected utility of the adviser is $U(s|s;k)) = 0$. Now, if $b(\mu_k) \leq s \leq 0$, then a number of voters no less than k will vote $x_i = Y$ with probability one. For those signals $s \in [b(\mu_k), 0)$ the adviser prefers rejection and, therefore, his interim utility is either $U(s|s;k) = -L$ or $U(s|s;k) = -\phi_k(S)L$. Since $\phi_k(S) \in (0, 1)$, it follows that the adviser finds stricly beneficial to concel such a set of signals $S = [b(\mu_k), 0)$. Given a signal $s \geq 0$ observed by the adviser, if he chooses to disclose it, then a number no less than $\frac{n}{s}$ voters will vote $x_i = Y$. Since the voting rule k satisfies $k \leq \frac{n}{2}$, it follows that the outcome of the electoral will be approval with probability one. For such signals $s \geq 0$ the adviser stricly prefers approval so that, by disclosing them, his interim utility is $U(s|s;k) = 0$. Therefore, the adviser optimally chooses $S(\mu_k, k) = [b(\mu_k), 0)$.

Consider a voting rule $k \in \{\frac{n}{2}+1, ..., n\}$. Note then that $\mu_k < 0$ - and thus $b(\mu_k) > 0$ - for the

kth (pivotal) voter, given the considered arreangement of the voters' prior beliefs. Given a signal $s < 0$ observed by the adviser, it follows that no more than $\frac{n}{2}$ voters will now vote $x_i = Y$ if the adviser decides to disclose such signals. Since the voting rule k satisfies $k > \frac{n}{2}$, we know that the outcome of the electoral will be rejection with probability 1 if the adviser discloses only such negative signals. For those signals $s < 0$ the adviser prefers rejection and, therefore, his interim utility is $U(s|s;k) = 0$. It follows that the adviser finds strictly beneficial to disclose all negative signals. Given a signal $s \geq 0$ observed by the adviser, then at least $\frac{n}{2}$ voters will vote for approval upon observing such nonnegative signals (voters i with $\mu_i > 0$). For $0 \leq s \leq b(\mu_k)$, only $k-1$ voters will vote for acceptance with probability 1 so that the outcome of the electoral will be approval with probability less than 1. In this case, $U(s|s;k) = -[1-\phi_k(S)]L$. Therefore, since the adviser prefers approval conditional on nonnegative signals and we have $\phi_k(S) \in (0,1)$, it follows that the adviser finds strictly beneficial to conceal such a set of signals $S = [0, b(mu_k))$. If the adviser observes and discloses a signal $s \geq b(\mu_k)$, then at least k voters will vote for approval with probability 1. For those signals $s \in [b(\mu_k), +\infty)$ the adviser's interim utility when he discloses the signal is $U(s|s;k) = 0$. As a consequence, he will optimally disclose such signals $s \geq b(\mu_k)$. Thefore, the adviser optimally chooses $S(\mu_k, k) = [0, b(\mu_k))$. $\square$

Proof of Proposition 2. Consider a voting rule $k \in \{1, ..., \frac{n}{2}\}$. Suppose that the adviser selects an effort level $p \in (0, \overline{p}]$. Then, with such probability p the adviser receives a signal $s \neq \emptyset$ and with probability $1-p$ a signal $s = \emptyset$.

First, since $\mu_0 = 0$, it follows that, conditional on obtaining a signal s, the adviser stricly prefers the electoral outcome of rejection with probability $\int_{-\infty}^{0} \gamma(s;0)\, ds = \frac{1}{2}$. Proposition 1 for $k \leq \frac{n}{2}$ showed that, at the interim stage, the adviser optimally chooses to conceal the set of singals $S(\mu_k, k) = [b(\mu_k), 0)$. In this case, the proof of Proposition 1 for a voting rule $k \leq \frac{n}{2}$ showed that the adviser will be able to induce acceptance with probability $\phi(S(\mu_k, k))$, so that his expected payoff will be $-L\phi(S(\mu_k, k)) \int_{s \in S(\mu_k, k)} \gamma(s;0)\, ds$. As mentioned, this outcome will be attained from an ex-ante perspective with probability $\frac{1}{2}p$. Similarly, if the advier obtains $s = \emptyset$, then he has no choice to make respect the nondisclosure set. In this case, the adviser (strictly) prefers the electoral outcome of rejection with probability $\int_{-\infty}^{0} \gamma(s;0)\,ds = \frac{1}{2}$. Since the pivotal voter $i = k$ is voting according to the probability $\phi(S(\mu_k, k))$, the adviser will obtain an expected payoff $-L\,[1 - \phi(S(\mu_k, k))]$ which will be attained from an ex-ante perspective with probability $\frac{1}{2}p$.

Secondly, the adviser (strictly) prefers the electoral outcome of acceptance with probability $\int_{0}^{\infty} \gamma(s;0)\,ds = \frac{1}{2}$, conditional on obtaining a signal, and, similarly, with probability $\int_{0}^{\infty} \gamma(s;0)\,ds = \frac{1}{2}$, conditional on obtaining no signal. However, provided that $k \in \{1, ..., \frac{n}{2}\}$, the proof of proposition 1 for $k \leq \frac{n}{2}$ showed that in such cases the adviser chooses optimally to disclose all obtained signals and, at the same time, the electoral outcome is approval with probability one. Thus, the adviser obtains a zero payoff in all those cases.

By combining all those arguments, it follows that the expected utility of the adviser in the ex-ante stage is

$$U_0(p;k) =$$

$$\frac{1}{2}p\left\{-L\,[1 - \phi(S(\mu_k, k))]\int_{s\in S(\mu_k,k)} \gamma(s;0)\,ds\right\} + \frac{1}{2}(1-p)\,[-L\,[1 - \phi(S(\mu_k, k))]] - c(p)$$

$$= -\frac{1}{2}L\phi(S(\mu_k, k))\left[1 - p\int_{s\notin S(\mu_k,k)} \gamma(s;0)\,ds\right] - c(p).$$

By normalizing respect $\frac{1}{2}$,

$$U_0(p;k) = -L\phi(S(\mu_k, k))\left[1 - p\int_{s\notin S(\mu_k,k)} \gamma(s;0)\,ds\right] - c(p).$$

Consider a voting rule $k \in \{\frac{n}{2} + 1, ..., n\}$. Suppose that the adviser selects an effort level $p \in (0, \overline{p}]$. Then, with such probability p the adviser receives a signal $s \neq \emptyset$ and with probability $1 - p$ a signal $s = \emptyset$.

First, since $\mu_0 = 0$, it follows that, conditional on obtaining a signal s, the adviser stricly prefers the electoral outcome of rejection with probability $\int_{0}^{\infty} \gamma(s;0)\,ds = \frac{1}{2}$. Proposition 1 for $k > \frac{n}{2}$ showed that, at the interim stage, the adviser optimally chooses to conceal the set of singals $S(\mu_k, k) = [0, b(\mu_k))$. In this case, the proof of Proposition 1 for a voting rule $k > \frac{n}{2}$

showed that the adviser will be able to induce rejection with probability $1 - \phi(S(\mu_k, k))$, so that his expected payoff will be $-L\left[1 - \phi(S(\mu_k, k))\right] \int_{s \in S(\mu_k,k)} \gamma(s;0)\, ds$. As mentioned, this outcome will be attained from an ex-ante perspective with probability $\frac{1}{2}p$. Similarly, if the advier obtains $s = \emptyset$, then he has no choice to make respect the nondisclosure set. In this case, the adviser (strictly) prefers the electoral outcome of approval with probability $\int_0^\infty \gamma(s;0)\, ds = \frac{1}{2}$. Since the pivotal voter $i = k$ is voting according to the probability $\phi(S(\mu_k, k))$, the adviser will obtain an expected payoff $-L\phi(S(\mu_k, k))$ which will be attained from an ex-ante perspective with probability $\frac{1}{2}p$.

Secondly, the adviser (strictly) prefers the electoral outcome of acceptance with probability $\int_{-\infty}^0 \gamma(s;0)\, ds = \frac{1}{2}$, conditional on obtaining a signal, and, similarly, with probability $\int_{-\infty}^0 \gamma(s;0)\, ds = \frac{1}{2}$, conditional on obtaining no signal. However, provided that $k \in \{1, ..., \frac{n}{2}\}$, the proof of proposition 1 for $k \leq \frac{n}{2}$ showed that in such cases the adviser chooses optimally to disclose all obtained signals and, at the same time, the electoral outcome is approval with probability 1. Thus, the adviser obtains a zero payoff in all those cases.

By combining all those arguments, it follows that the expected utility of the adviser in the ex-ante stage is

$$U_0(p;k) =$$

$$\frac{1}{2}p\left[-L\left[1 - \phi(S(\mu_k, k))\right] \int_{s \in S(\mu_k,k)} \gamma(s;0)\, ds\right] + \frac{1}{2}(1-p)\left[-L\left[1 - \phi(S(\mu_k, k))\right]\right] - c(p)$$

$$= -\frac{1}{2}L\left[1 - \phi(S(\mu_k, k))\right]\left[1 - p\int_{s \notin S(\mu_k,k)} \gamma(s;0)\, ds\right] - c(p).$$

By normalizing respect $\frac{1}{2}$,

$$U_0(p;k) = -L\left[1 - \phi(S(\mu_k, k))\right]\left[1 - p\int_{s \notin S(\mu_k,k)} \gamma(s;0)\, ds\right] - c(p).\square$$

Proof of Proposition 3. Recall equation 3.1. Let $\Gamma(k;s,0) = \int_{s \in S(\mu_k,k)} \gamma(s;0)\, ds$. By deriving respect to k the adviser's expected utility function we can se how changes in the voting rule affects him,

$$\frac{\partial U(k; S(\mu_k, k), p^*(k))}{\partial k} =$$

$$-L\left[-\frac{\partial p^*(k)}{\partial k} + \frac{\partial p^*(k)}{\partial k}\Gamma(k; s, 0) + p^*(k)\frac{\partial \Gamma(k; s, 0)\, ds}{\partial k}\right] - \frac{\partial c(p^*(k))}{\partial p^*(k)}\frac{\partial p^*(k)}{\partial k}$$

$$= L\left[\frac{\partial p^*(k)}{\partial k}[1 - \Gamma(k; s, 0)] - p^*(k)\frac{\partial \Gamma(k; s, 0)\, ds}{\partial k}\right] - \frac{\partial c(p^*(k))}{\partial p^*(k)}\frac{\partial p^*(k)}{\partial k} \tag{A.1}$$

For a voting rule $k \leq \frac{n}{2}$, as the voting rule becomes more demanding, the adviser decides to disclose more signals, so $\frac{\partial \Gamma(k;s,0)\, ds}{\partial k}$<0 at the same time he puts more effort, so $\frac{\partial p^*(k)}{\partial k} > 0$; this implies that

$$L\left[\frac{\partial p^*(k)}{\partial k}[1 - \Gamma(k; s, 0)] - p^*(k)\frac{\partial \Gamma(k; s, 0)\, ds}{\partial k}\right] > 0$$

and

$$\frac{\partial c(p^*(k))}{\partial p^*(k)}\frac{\partial p^*(k)}{\partial k} > 0.$$

In this case, as the voting rule is more strict, the adviser has more marginal gains from selecting a higher effort level, but the marginal cost incrases because he puts more effort.

In contrast, for a voting rule $k > \frac{n}{2}$, as the voting rule becomes more demanding, the adviser decides to disclose less signals, so $\frac{\partial \Gamma(k;s,0)\, ds}{\partial k} > 0$, and at the same time he exerts less effort, $k \leq \frac{n}{2}$ $\frac{\partial p^*(k)}{\partial k} < 0$; this implies that

$$L\left[\frac{\partial p^*(k)}{\partial k}[1 - \Gamma(k; s, 0)] - p^*(k)\frac{\partial \Gamma(k; s, 0)\, ds}{\partial k}\right] < 0$$

and

$$\frac{\partial c(p^*(k))}{\partial p^*(k)}\frac{\partial p^*(k)}{\partial k} < 0.$$

As the voting rule is more strict, the adviser has less marginal gains from selecting a higher effort level, but the marginal cost reduces because he exerts less effort.

Suppose that the marginal cost is never higher than the marginal gains. Thus, we can infer that $\frac{\partial U(k;S(\mu_k,k),p^*(k))}{\partial k} \geq 0$ for $k \leq \frac{n}{2}$ and $\frac{\partial U(k;S(\mu_k,k),p^*(k))}{\partial k} \leq 0$ for $k > \frac{n}{2}$. So, the adviser can obtain a higher net marginal utility with a more demanding whenever $k \leq \frac{n}{2}$ or by selecting a less strict voting rule whenever $k > \frac{n}{2}$. In other words, he obtains a higher utility by increasing the probability of obtaining a favorable signal, that is, a signal outside the nondisclosure set. So, the adviser optimally selects a voting rule k^* such that $b(\mu_{k^*}) = \min\{|b(\mu_{\frac{n}{2}})|, |b(\mu_{\frac{n}{2}+1})|\}$. $\square$

Proof of Proposition 4. Suppose that a social planner has the objective to maximize the committee's welfare in the ex-ante stage of the model. In order to accomplish this objective, he must maximize the probability that $\frac{n}{2}+1$ or more voters receive payoff of 0 or, equivalently, minimizes the probability that less than $\frac{n}{2}+1$ voters receive payoff of 0, that is, $P(|i \in N | u_i = 0| < \frac{n}{2}+1)$. Without loss of generality, suppose that the social planner believes that the mean of the state of the world is $\mu_s = 0$ and suppose that the adviser selects an effort level p^*. Then, with such probability p^* the adviser receives a signal $s \neq \emptyset$ and with probability $1 - p^*$ receives a signal $s = \emptyset$.

(a) Consider an arbitray voting rule $k \in \{1, ..., \frac{n}{2}\}$. First, since $\mu_s = 0$, it follows that, conditional on the adviser observing a signal, the social planner believes that the state of the world has a negative value with probability $\int_{-\infty}^{0} \gamma(s; 0)\, ds = \frac{1}{2}$, and, similarly, with probability $\int_{-\infty}^{0} \gamma(s; 0)\, ds = \frac{1}{2}$ on observing no signal. For this voting rule, there is a pivotal voter $i = k$ with $\mu_k > 0$ and, hence, $b(\mu_k) < 0$. Proposition 1 for $k \leq \frac{n}{2}$ showed that, in the interim stage, the adviser optimally chooses to conceal the set of signals $S(\mu_k, k) = [b(\mu_k), 0)$. In this case, the proof of Proposition 1 for a voting rule $k \leq \frac{n}{2}$ showed that the adviser will be able to induce acceptance with probability $\phi(S(\mu_k, k))$.

In the interim stage the social planner believes that the adviser can receive a signal $s < b(\mu_k)$ with probability $\int_{-\infty}^{b(\mu_k)} \gamma(s; 0)\, ds$. Conditional on observing such a signal, the adviser optimally discloses signal $s < b(\mu_k)$. Recall equition 2.1. Voters with $\mu_i < 0$ (strictly) prefer the rejection of the proposal – since $s < 0$, $s < b(\mu_i)$ for $i = \{\frac{n}{2}+1, ..., n\}$. Also, notice that the pivotal voter $i = k$ and all voters with $0 < \mu_i < \mu_k$ (stricly) prefer to reject the proposal too –$s < b(\mu_k)$, so $s < b(\mu_i)$ with $i \in \{k, ..., \frac{n}{2}\}$. In consequence, there are at least k voters cast their vote against the proposal and the committee rejects the proposal with probability 1 and, aditionally, there are at least $\frac{n}{2} + 1$ voters that receive payoff of 0. Therefore, the social planner believes that at least

$\frac{n}{2}+1$ voters receive a payoff of 0 with probability $\int_{-\infty}^{b(\mu_k)}\gamma(s;0)\,ds$ in the interim stage.

Now, the social planner also believes that the adviser can receive a signal $s\in S(\mu_k,)$ with probability $\int_{s\in S(\mu_k,k)}\gamma(s;0)\,ds$. If the adviser received such a signal, he will concel it. Notice that, since the pivotal voter $k=i$ determines the outcome of the committee decision, she always receives a payoff of 0. Recall equation 2.7. Voters i with $\mu_i<0$ (stricly) prefer to reject the proposal and, since with probability $\phi(S(\mu_k,k))$ the committee approves the proposal under nondisclosure, $\frac{n}{2}$ voters obtain payoff of 0 with probability $1-\phi(S(\mu_k,k))$. In contrast, voters i with $\mu_k<\mu_i$ will (strictly) prefer to approve the proposal and, hence, cast their vote accordingly; in such a case, voters i with $\mu_k<\mu_i$ would receive payoff of 0 with probability $\phi(S(\mu_k,k))$. Voters i with prior believes $0<\mu_i<\mu_k$ prefer approval with probability $1-q(S(\mu_k,k),\mu_i)$; individually, each voter i with $0<\mu_i<\mu_k$ would prefer approval too with probability $q(S(\mu_k,k),\mu_i)$ if $b(\mu_i)<\int_{S(\mu_k,k)}s\gamma(s;0\mu_i)\,ds$ and, hence, cast their vote in favor of the proposal with probability 1. If, by contrast, $\int_{S(\mu_k,k)}s\gamma(s;\mu_i)\,ds<b(\mu_i)$, a voter i would prefer to reject the proposal with probability $q(S(\mu_k,k),\mu_i)$. If we consider that the expected value of signal $s\in S(\mu_k,k)$ lies between $b(\mu_k)$ and 0, $b(\mu_k)<\int_{S(\mu_k,k)}s\gamma(s;0)\,ds$ and, hence, probability $\phi(S(\mu_k,k))=1$. With this consideration, in any case, whenever the adviser observes a signal $s\in S(\mu_k,k)$, half of the voters –voters i with $\mu_i<0$– will always receive a payoff $-L$. So, the social palneer believes that less than $\frac{n}{2}+1$ voters receive payoff of 0 with probability $\int_{s\in S(\mu_k,k)}\gamma(s;0)\,ds$ in the interim stage. Similarly, if the adviser obtains no signal, that is, $s=\emptyset$, half of the voters would receive payoff $-L$ in the interim stage –all voters i with $\mu_i<0$ (strictly) prefer rejection and $\phi(S(\mu_k,k))=1$. So, the social planner believes that whenever the adviser observes no signal, the probability that less than $\frac{n}{2}+1$ voters receive payoff of 0 is 1.

Secondly, the social planner believes that the state of the world has a positive value with probability $\int_0^{\infty}\gamma(s;0)\,ds=\frac{1}{2}$. The social planner also believes that adviser can observe a signal $s\in[0,b(\mu_{\frac{n}{2}+1}))$ with probability $\int_0^{b(\mu_{\frac{n}{2}+1})}\gamma(s;0)\,ds$. Conditional on observing such a signal, the adviser will optimally disclose it. Voters i with $\mu_i<0$ (strictly) prefer the rejection of the proposal while voters with $\mu_i < 0$ prefer the approval of the proposal. For a voting rule $k \leq \frac{n}{2}$, there are enough voters to approve the proposal and, therefore, half of voters receive payoff of 0 and the other half $-L$. So, the social planner believes that less than $\frac{n}{2}+1$ voters will receive payoff of 0 with probability $\int_0^{b(\mu_{\frac{n}{2}+1})} ds$ in the interim stage. Also, the adviser can receive a signal $s > b(\mu_{\frac{n}{2}+1})$ with probability $\int_{b(\mu_{\frac{n}{2}+1})}^{\infty} \gamma(s;0)\, ds$. Conditional on observing such a signal, it is straightforward $\frac{n}{2}+1$ voters or more would receive a payoff of 0. The adviser will disclose signal $s > b(\mu_{\frac{n}{2}+1})$ and voters i with $\mu_i > 0$ want to approve the proposal, and at least voter $\frac{n}{2}+1$ would like to approve the proposal too. For such a signal and the voting rule $k \leq \frac{n}{2}$, there are enough voters to approve the proposal, so, at least $\frac{n}{2}+1$ voters would receive payoff of 0 in the interim stage with probability $\int_{b(\mu_{\frac{n}{2}+1})}^{\infty} \gamma(s;0)\, ds$.

By taking all of this considerations into account, for a voting rule $k > \frac{n}{2}$, the probability that less than $\frac{n}{2}+1$ voters receive a payoff of 0 with an ex-ante perspective is

$$P\left(|i \in N | u_i = 0| < \frac{n}{2} + 1\right) =$$

$$\frac{1}{2}p^*\left[\int_{s\in S(\mu_k,k)} \gamma(s;0)\, ds + \int_0^{b(\mu_{\frac{n}{2}+1})} \gamma(s;0)\, ds\right] + \frac{1}{2}(1-p^*) =$$

$$-\frac{1}{2}p^*\left[1 - \int_{s\in S(\mu_k,k)} \gamma(s;0)\, ds - \int_0^{b(\mu_{\frac{n}{2}+1})} \gamma(s;0)\, ds\right] + \frac{1}{2} =$$

$$-\frac{1}{2}p^*\left[\int_{s\notin S(\mu_k,k)} \gamma(s;0)\, ds - \int_0^{b(\mu_{\frac{n}{2}+1})} \gamma(s;0)\, ds\right] + \frac{1}{2} \tag{A.2}$$

(b) Consider an arbitray voting rule $k \in \{\frac{n}{2}+1, ..., n\}$. First, since $\mu_s = 0$, it follows that the social planner believes that the state of the world has a negative value with probability $\int_{-\infty}^{0} \gamma(s;0)\, ds = \frac{1}{2}$. For this voting rule, there is a pivotal voter $i = k$ with $\mu_k < 0$ and, hence, $b(\mu_k) > 0$. Proposition 1 for $k > \frac{n}{2}$ showed that, in the interim stage, the adviser optimally chooses to conceal the set of signals $S(\mu_k, k) = [0, b(\mu_k))$. In this case, the proof of Proposition 1 for a voting rule $k > \frac{n}{2}$ showed that the adviser will be able to induce rejection with probability $1 - \phi(S(\mu_k, k))$.

In the interim stage the social planner believes that the adviser can receive a signal $s < b(\mu_{\frac{n}{2}})$ with probability $\int_{-\infty}^{b(\mu_{\frac{n}{2}})} \gamma(s;0)\,ds$. Conditional on observing such a signal, the adviser optimally discloses signal $s < b(\mu_{\frac{n}{2}})$. Recall equition 2.1. Voters with $\mu_i < 0$ (strictly) prefer the rejection of the proposal – since $s < b(\mu_{\frac{n}{2}}) < 0$, $s < b(\mu_i)$ for $i = \{\frac{n}{2}+1, ..., n\}$. Aditionally, at least voter $i = \frac{n}{2}$ (strictly) prefers to reject the proposal too – since $s < b(\mu_{\frac{n}{2}})$. For this voting rule $k > \frac{n}{2}$, there are no enough votes to approve the proposal and, hence, the committee rejects its implementation. So, at least $\frac{n}{2}+1$ voters receive payoff of 0 and the social planner believes that with probability $\int_{-\infty}^{b(\mu_{\frac{n}{2}})} \gamma(s;0)\,ds$ this will occur. Also, the social planner believes that the adviser can receive a signal $s \in [b(\mu_{\frac{n}{2}}), 0)$ with probability $\int_{b(\mu_{\frac{n}{2}})}^{0} \gamma(s;0)\,ds$ in the interim stage. Also, the social planner believe that the adviser can receive a signal $s \in [b(\mu_{\frac{n}{2}}), 0)$ with probability $\int_{b(\mu_{\frac{n}{2}})}^{0} \gamma(s;0)\,ds$. Conditional on observing such a signal, the adviser will disclose it and voters i with $\mu_i < 0$ will reject the proposal while voters with $\mu_i > 0$ want to approve the proposal. For the voting rule $k > \frac{n}{2}$, there are not enough voters to approve the proposal and, hence, the committee do not approves the proposal. So, the social planner beleifs that less than $\frac{n}{2}$ voters will receive payoff of 0 with probability $\int_{b(\mu_{\frac{n}{2}})}^{0} \gamma(s;0)\,ds$.

Secondly, the social planner believes that conditional on the adviser observing a signal, the world is positive with probability $\int_{0}^{\infty} \gamma(s;0)\,ds = \frac{1}{2}$, and, similarly, with probability $\int_{0}^{\infty} \gamma(s;0)\,ds = \frac{1}{2}$ on observing no signal. The social planner also believes that the adviser can observe a signal $s \in S(\mu_k, k)$ with probability $\int_{s \in S(\mu_k,k)} \gamma(s;0)\,ds$. If the adviser received such a signal, he will concel it. Notice that, since the pivotal voter $k = i$ determines the outcome of the committee decision, she always receives a payoff of 0. Recall equation 2.7. Voters i with $\mu_i > 0$ (stricly) prefer the approval of the proposal and, since with probability $\phi(S(\mu_k, k))$ the committee approves the proposal under nondisclosure, in the interim stage $\frac{n}{2}$ voters obtain payoff of 0 with probability $\phi(S(\mu_k, k))$. In contrast, voters i with $\mu_i < \mu_k$ will (strictly) prefer to reject the proposal and, hence, cast their vote to reject the proposal; in such a case, voters i with $\mu_i < \mu_k$ would receive payoff of 0 with probability $1 - \phi(S(\mu_k, k))$ in the interim stage. Voters i with prior believes $\mu_k < \mu_i < 0$ prefer rejection with probability $1 - q(S(\mu_k, k), \mu_i))$; individually, each voter i with $0 < \mu_i < \mu_k$ would prefer rejection too with probability $q(S(\mu_k, k), \mu_i))$ if $\int_{S(\mu_k,k)} s\gamma(s;\mu_i)\,ds < b(\mu_i)$ and, hence, cast their vote against the proposal with probability 1. If, by contrast, $b(\mu_i) < \int_{S(\mu_k,k)} s\gamma(s;\mu_i)\,ds$, a voter i would prefer to approve the proposal with probability $q(S(\mu_k, k), \mu_i))$. If we consider that the expected value of signal $s \in S(\mu_k, k)$ lies between 0 and $b(\mu_k)$, $\int_{S(\mu_k,k)} s\gamma(s;0)\,ds < b(\mu_k)$ and, hence, probability $\phi(S(\mu_k, k)) = 0$. With this consideration, in any case, whenever the adviser observes a signal $s \in S(\mu_k, k)$, half of the voters –voters i with $\mu_i > 0$– will always receive a payoff $-L$. So, the social palneer believes that less than $\frac{n}{2} + 1$ voters receive payoff of 0 with probability $\int_{s\in S(\mu_k,k)} \gamma(s;0)\,ds$ in the interim stage. Similarly, if the adviser obtains no signal, that is, $s = \emptyset$, half of the voters would receive payoff $-L$ in the interim stage –all voters i with $\mu_i < 0$ (strictly) prefer rejection and $\phi(S(\mu_k, k)) = 1$. So, the social planner believes that whenever the adviser observes no signal, the probability that less than $\frac{n}{2} + 1$ voters receive payoff of 0 is 1.

By taking all of this considerations into account, for a voting rule $k > \frac{n}{2}$, the probability that less than $\frac{n}{2} + 1$ voters receive a payoff of 0 with an ex-ante perspective is

$$P\left(|i \in N|u_i = 0| < \frac{n}{2} + 1\right) =$$

$$\frac{1}{2}p^*\left[\int_{s\in S(\mu_k,k)} \gamma(s;0)\,ds + \int_{b(\mu_{\frac{n}{2}})}^{0} \gamma(s;0)\,ds\right] + \frac{1}{2}(1-p^*) =$$

$$-\frac{1}{2}p^*\left[1 - \int_{s\in S(\mu_k,k)} \gamma(s;0)\,ds - \int_{b(\mu_{\frac{n}{2}})}^{0} \gamma(s;0)\,ds\right] + \frac{1}{2}$$

$$-\frac{1}{2}p^*\left[\int_{s\notin S(\mu_k,k)} \gamma(s;0)\,ds - \int_{b(\mu_{\frac{n}{2}})}^{0} \gamma(s;0)\,ds\right] + \frac{1}{2}. \tag{A.3}$$

Now, notice from equations A.2 and A.3, the voting rule has two indirect effects on probability $P\left(|i \in N|u_i = 0| < \frac{n}{2} + 1\right)$: the effect it has over the effort level p^*, and the probability $\int_{s\notin S(\mu_k,k)} \gamma(s;0)\ ds$. Recall equation 3.4; the optimal effort level p^* that the adviser exerts depends on the voting rule k. On the one hand, equation 3.6 showed that for a voting rule $k \leq \frac{n}{2}$, as the voting rule k changes to one that is more strict, the adviser exerts more effort. On the other hand, equation 3.7 showed that for a voting rule $k > \frac{n}{2}$, as the voting rule changes to one that is more strict, the adviser exerts less effort, respectively. In both cases, a voting rule that is closer to either to $\frac{n}{2}$ or $\frac{n}{2}+1$ increases the probability that the adviser obtains a favorable signal ($\int_{s \notin S(\mu_k,k)} \gamma(s;0)\, ds$). Indeed, both the effort level p^* and the probability $\int_{s \notin S(\mu_k,k)} \gamma(s;0)\, ds$ are maximized when the voting rule is closer to either $k = \frac{n}{2}$ and $k = \frac{n}{2}+1$. Therefore, $P\left(|i \in N|u_i = 0| < \frac{n}{2}+1\right)$ is minimized when the social planer selects a voting rule $k^* = \{\frac{n}{2}$ or $k^* = \frac{n}{2}+1\}$, particularly, a voting rule k^* such that $b(\mu_{k^*}) = \min\{|b(\mu_{\frac{n}{2}})|, |b(\mu_{\frac{n}{2}+1})|\}$. $\square$

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