Evaluating political decision makers: With the benefit of hindsight bias?*

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Abstract

In this paper we present a political-agency model where voters exhibit a cognitive deficiency known as hindsight bias: after the uncertainty about an event is resolved, they think that the realized outcome was more foreseeable than it actually was. For their reelection decision, voters evaluate the politician's ability based on the history of observed actions and outcomes. High ability is defined as an informational advantage over voters as to the welfare maximizing policy, creating incentives for low-ability politicians to deviate from the optimal policy choice in an attempt to be perceived as possessing superior private information. We show that, because hindsight biased voters are less impressed than rational voters when a reform succeeds in spite of public pessimism, the bias acts as a discipline device on low-ability politicians. It also increases political turnover compared to fully rational evaluation. While hindsight bias benefits voters in terms of politicians' discipline, its effects on selection are ambiguous. These insights may be relevant to other principal-agent relationships in which hindsight bias cannot be eliminated through explicit ex ante contracts, e.g. promotion decisions in organizations.

Keywords: political agency, hindsight bias, bounded rationality, beliefs
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1 Introduction

It is well documented in psychology literature that many human beings exhibit hindsight bias, a phenomenon also known as the "I-knew-it-all-along" effect: in retrospect, people systematically overestimate the degree to which events were predictable. Starting with the work of Fischhoff (1975), there has been an extraordinary amount of psychological research which has firmly established the robustness of this cognitive bias.[1] It is not limited to college students but also affects surgeons, judges and other experts.[2] Moreover, teaching people to avoid the bias has proven tremendously difficult.[3] Given its pervasiveness, it has been suggested that hindsight bias is also likely to be of practical importance, as it may cause problems in a number of real-world situations where a decision maker is evaluated after the outcome of his actions is known, and where there is no explicit ex ante contract mapping outcomes into performance assessments. This includes situations as diverse as courts judging the liability of an injurer, voters in a democratic election assessing the competence of a politician, human resource managers choosing whether to promote an employee, or an organization deciding whether to re-appoint an expert. In all of those cases, hindsight bias can be expected to decrease the accuracy of the evaluation.[4]

Take the example of courts having to determine whether a defendant who caused an accident acted negligently, i.e., whether or not he took "reasonable" care. If judges and juries suffer from hindsight bias, defendants appear more culpable than they are because it seems they should have foreseen that their actions would lead to adverse events (Rachlinski, 1998; Harley, 2007). The bias will lead courts to hold liable even defendants who took precautions that, given the information available at the time, were entirely reasonable. What is more, hindsight bias may, if anticipated, lead to excessive precautions. As pointed out by Rachlinski (1998), the legal system has long recognized the dangers of judging in hindsight.[5] Moreover, Rachlinski argues that courts have adopted various measures to mitigate the effects

[1] For an extensive review of the vast literature on hindsight bias consult Hawkins and Hastie (1990).

[2] Hindsight bias has been demonstrated by Detmer *et al.* (1978) in surgeons and by Anderson *et al.* (1993) in state and federal judges.

[3] See, e.g., Hoch and Loewenstein (1989). The difficulty of eliminating the bias can partly be attributed to the fact that it is mainly of a cognitive nature, as we discuss below. Therefore, motivational forces such as monetary incentives which increase subjects' effort to avoid the bias have little effect.

[4] The consequences of hindsight bias are not limited to these kinds of situations. It is also said to impair learning from the past by portfolio managers (Biais and Weber, 2006) or strategic planners (Bukszar and Connolly, 1988).

[5] For example, the United States Court of Appeals (2nd circuit) is quoted as saying in *Joy vs. North* (692 F2d at 886 (1982)): "Courts recognize that after-the-fact litigation is a most imperfect device to evaluate (...) decisions. The circumstances surrounding a (...) decision are not easily reconstructed in a courtroom years later... [A] reasoned decision at the time made may seem a wild hunch viewed years later against a background of perfect knowledge."

of hindsight bias, and have been quite successful in containing it.[6]

In many respects, voters in a democracy have a task that is similar to that of jurors or judges in a court of law; much like the latter have to assess whether a defendant made the right choices concerning precautionary measures, the former need to evaluate whether an incumbent took the right decisions regarding the policies he implemented (or failed to implement). Given this similarity, one might expect that hindsight bias is as problematic in the political system as in the legal system. Camerer *et al.* (1989, p. 1246), for example, voice concerns that the problem caused by hindsight bias should be "especially acute in public decision making, in which principals are a diffuse group of voters and contracts are rarely explicit." [7]

Nevertheless, political institutions, unlike the law, do not seem to have developed measures to hold hindsight bias in check. How can one explain this discrepancy? In this paper we argue that democratic elections are different from liability assessments in an important way, and that hindsight bias may be less detrimental to the political system than to the legal system – surprisingly, we show that voters may even benefit from being hindsight biased. The problem that liability law addresses is that agents may take little or no precautions to avoid harming others if they cannot be held liable for the harm they cause. Thus, there is a fundamental conflict of interest between (potential) injurers and society, and liability law is designed to give agents incentives to take the efficient level of care. By contrast, democratic elections serve a different purpose, namely, selecting the most able politician to run a country's affairs. There may not be as fundamental a conflict of interest between politicians and society because social welfare probably is an argument of (many) politicians' utility function.[8]

Of course, politicians also like being in office.[9] As a result, reelection, while useful for

[6] According to Rachlinski (1998, p. 575), "Judicial opinions display a terrific understanding of the implications of a biased assessment of liability. Rules have evolved that reduce the bias's impact, and when its influence cannot be purged, sensible second-best rules have emerged. The law has adapted well to the fallibility of human judgment." Among the examples of rules to reduce the bias he cites is suppression of evidence (namely, the inadmissibility of post-accident remedial measures taken by the defendant as proof of negligence), using the profession's ex ante customs as standard of "reasonableness" (as in medical malpractice cases) and the adoption of no-liability rules (such as the business judgment rule: corporate executives generally are not liable to shareholders for decisions that turn out badly).

[7] Frey and Eichenberger (1991) and Gowda (1999) also mention the bias in connection with politics.

[8] This view is reflected in the utility function we ascribe to the politician in our formal model below: we posit that all types of politician care only about social welfare and holding office. For example, since a politician is drawn from the population of voters, he can be expected to consume the same goods as the rest of the electorate. While this formulation follows authors such as Rogoff (1990), Harrington (1993), Canes-Wrone *et al.* (2001) and Majumdar and Mukand (2004), one should note that it is in contrast with the majority of political agency models which assume that at least some types of politician have their own agenda. This is true for the early work of Barro (1973) and Ferejohn (1986) who use a pure moral hazard framework, but also for more recent contributions who, for the most part, assume that there are both "good" and "bad" types of politician, where "good" types generally have objectives which are "congruent" with society's (see, e.g., Coate and Morris (1995), Maskin and Tirole (2004) and Smart and Sturm (2006)).

[9] The assumption that politicians derive some private benefit (sometimes termed "ego rent") from being

selection purposes, introduces reputation concerns which tend to distort politicians' objective away from society's: knowing that they need to run for reelection, politicians care not only about social welfare, but also about voters' perception of their competence which determines their chances of being reelected. In our model, the politician's reputation concerns will sometimes lead him to make socially suboptimal (and unpopular) choices in an attempt to appear to have superior private information. If his gamble pays off, rational voters are "surprised" and make an upward adjustment of their beliefs about the politician's ability. Hindsight biased voters, however, think they knew all along that the policy was going to work (they are not surprised), and do not give him as much credit. Therefore, when facing hindsight biased voters, the politician is less tempted to engage in such behavior in the first place. Hindsight bias is a distortion that works against another distortion – namely, costly signaling by politicians – and as a result, can be welfare-enhancing.

To be more specific, in the model developed in this paper, a politician whose ability is unknown to voters has to choose between a status quo policy whose payoff is certain and a reform policy whose payoff is uncertain. While voters and low-ability politicians obtain only an imperfect signal of which policy is preferable ex ante, high-ability politicians know the state of the world with certainty. We assume that the public signal is informative enough to make it optimal, in terms of welfare, for the low-ability politician to always choose the policy suggested by the signal. This setup creates incentives for the low-ability politician to inefficiently ignore publicly available information about the welfare-maximizing policy in an attempt to "look smart", i.e., to make it seem as if he had superior private information, the trademark of competent politicians. To see why, consider what happens in case of fully rational voters, noting that a high-ability politician always chooses the right policy and thus disregards the publicly observed signal. If the low-ability politician always followed the signal, rational voters would infer that any politician who chooses a policy that is contrary to the signal must be of high ability; thus, choosing an unpopular policy acts as a signal of competence. We show that if the signal is not too precise and the politician cares sufficiently about reelection, the equilibrium with fully rational voters has the low-ability politician randomizing between choosing the policy suggested by the signal and doing exactly the opposite. Of course, this randomizing behavior is detrimental to welfare because policy choices are not optimal given the available information.

We assume that voters suffering from hindsight bias distort their recollection of the signal so as to make it consistent with the realized outcome. If the signal suggested that maintaining the status quo was optimal, but the politician enacts a successful reform, then voters wrongly believe that the signal had suggested all along that reform was the right choice (they think they

in office is standard in the political economy literature.

knew it all along). Therefore, with hindsight biased voters, some of the gain in reputation that follows from an unpopular policy which then turns out to be a success is destroyed, because ex post, biased voters think that it was the obvious choice anyway. We assume that politicians are aware of voters' behavioral decision making.[10] Anticipating the voters' biased belief updating, the low-ability politician chooses a suboptimal policy less often when voters are hindsight biased then when they are perfectly rational. Thus, hindsight bias on the part of voters acts as a discipline device by reducing incentives for the low-ability politician to engage in inefficient signaling.

The disciplining effect of hindsight biased policy evaluation is unambiguously beneficial for voters' first-period welfare. However, an overall welfare assessment also has to take into account the second (i.e., post-election) period. We analyze how hindsight bias affects the selection of the second period politician and show that, under some conditions, both the low- and the high-ability politician are less likely to be reelected. Hence, hindsight biased evaluation increases political turnover. The overall selection effect, meanwhile, is ambiguous: depending on parameters, hindsight bias may increase or decrease voters' second-period welfare. These qualifications notwithstanding, if voters discount future payoffs at a sufficiently high rate, hindsight bias can be welfare-enhancing regardless of what happens in the second period.

Related literature

Our contribution to the literature is twofold; the first is in terms of behavioral economics, the second in terms of political economy. As noted by Thaler (2000), while behavioral economists have come a long way towards understanding the implications of bounded rationality, a second aspect which Thaler calls "bounded memory" has been somewhat neglected. Thaler identifies hindsight bias as one of the more promising areas of research. To our knowledge, our paper is the first theoretical contribution that deals with hindsight bias in an economic context.[11]

Our (seemingly paradoxical) result that a behavioral bias can improve welfare is similar in spirit to Compte and Postlewaite (2004), Bénabou and Tirole (2002) and Köszegi (2000). Those papers, however, consider how a psychological bias (namely, overconfidence) affects

[10] This is in line with statements from political scientists who acknowledge that "politicians typically have a strong intuitive understanding of voters' heuristics and biases" (Gowda, 1999, p. 71).

[11] While there are experimental studies even by economists concerning the bias (see Camerer *et al.* (1989), Biais and Weber (2006)), theoretical economists have shunned analysis of hindsight bias so far. This is curious, but can possibly be explained by the fact that economists may have deemed the bias largely irrelevant. Indeed, in a standard principal-agent context, hindsight bias has no bite because an ex ante contract specifies exactly how the transfer from the principal to the agent depends on outcomes. Nevertheless, we think that the examples given at the outset demonstrate that there are a number of situations that bear some interest for economists in which the bias is likely to play a role.

intrapersonal welfare.[12] By contrast, we investigate how a bias on the part of one group of agents (voters) can affect the behavior of other agents (politicians) in a way that increases the former's welfare.[13] Moreover, we are able to use a standard welfare measure that is unaffected by which "self" of an individual one considers. Neither does it involve belief consumption.

Our paper also extends the literature on political agency,[14] in particular by going beyond the standard rational-voter assumption and instead considering behavioral decision making, as suggested by Besley (2006). Moreover, our basic model is related to the recent literature on the dysfunctional effects of electoral accountability which can arise when politicians have better information than voters. Majumdar and Mukand (2004), whose basic model is quite similar to ours, demonstrate that reelection concerns may lead to inefficient experimentation and policy persistence. Harrington (1993) shows that, in the presence of reelection pressures, an otherwise benevolent politician may choose the policy most likely to be well received by voters, rather than the one he himself believes to be welfare maximizing. Similarly, in Maskin and Tirole (2004) and Smart and Sturm (2006), reelection concerns not only reduce opportunism by bad politicians, but also distort good politicians' behavior. Politicians may diverge from their preferred (and socially optimal) policy, and choose a popular policy instead, in order to signal their congruence with voters, a behavior sometimes referred to as pandering. In Dewatripont and Seabright (2006), politicians signal that they care about voters through wasteful spending on public projects. In the paper most closely related to ours, Canes-Wrone *et al.* (2001) investigate the case where politicians try to signal their competence, rather than their congruence. They also obtain a pandering result: in their model, politicians may choose a suboptimal policy simply because it is popular among voters, provided that there is a low probability of voters learning the policy outcome before the election. Pandering contrasts with the inefficiency in our model, where politicians signal their ability by choosing an *unpopular* policy. Canes-Wrone *et al.* (2001), however, also derive cases for which politicians may engage in something they call "fake leadership": politicians act against both popular belief and their private signal in an attempt to be perceived as a "leader".[15] Albeit obtained in a different

[12] In Compte and Postlewaite (2004), an agent's self-confidence affects his performance at a task. Information-processing biases such as repressing memories of bad performance can improve the individual's welfare by boosting his confidence, thus helping him do better. Bénabou and Tirole (2002) show how overconfidence can help an individual overcome time inconsistency and thus improve his well-being (at least from an ex ante ("self zero") perspective). Köszegi (2000) lets individuals consume their own self-perception, so that an overly positive self-image can raise utility.

[13] Camerer *et al.* (1989) do speculate on the fact that a related phenomenon which they refer to as the "curse of knowledge" may be welfare-enhancing by (partly) eliminating market inefficiencies caused by asymmetric information. Their argument is very different from ours, though.

[14] See Persson and Tabellini (2000) or Chapter 3 in Besley (2006) for a recent overview of political agency models.

[15] Maskin and Tirole (2004) also report that in their model there exists an equilibrium with what they call "unpopular pandering", i.e., politicians signaling congruence through the choice of an unpopular policy.

model, this behavior is reminiscent of that displayed by low-ability politicians in our model.[16]

Low-ability politicians' behavior also bears some resemblance to Allen and Gorton (1993), where bad brokers pretend to have superior private information allowing them to identify undervalued stocks, but actually just speculate, and to models where players have a strategy labeled "gambling for resurrection" (see Downs and Rocke (1994) for a political economy application), since they are choosing a policy that is a long shot.

At a more abstract level, the model is related to Prat (2005). In his paper, the principal may be better off not observing the agent's action since the principal's knowledge of the action can lead the agent to disregard valuable private information in an attempt to mimic the more able type.[17] In a sense, hindsight bias in our model leads to a loss of information for voters (albeit on the original signal, rather than on the action). Just like in Prat (2005), less information can be better for voters than more.[18]

One important departure from the political economy literature is our assumption that voters obtain an informative signal about the state of the world, just like politicians do, and that this signal coincides with that of low-ability politicians. This reflects the idea that voters are exposed to a certain amount of policy relevant public information (e.g. from the media). Note that, nevertheless, politicians *on average* still have "expertise", i.e., they are more likely to have correct information concerning the underlying state of the world than voters.

The remainder of the paper is organized as follows. Section 2 introduces the main model while section 3 then establishes the benchmark rational policy evaluation equilibrium. In section 4 we define a hindsight bias information structure, determine the equilibrium under biased policy evaluation and compare it to the rational equilibrium. A discussion follows thereafter. Selection and welfare implications of hindsight biased policy evaluation are studied in section 5. Finally, section 6 concludes. All proofs are relegated to the Appendix.

[16] In this context, it is interesting to note that, while conventional wisdom holds that pandering on the part of politicians is common, this view is far from unanimous among political scientists; see, for example, Jacobs and Shapiro (2000) whose book is provocatively titled "Politicians Don't Pander". The authors claim that politicians' responsiveness to public opinion has been low over the past decades. This view is backed by Monroe (1998) who finds that only 55 percent of policies enacted in the US between 1980 and 1993 were consistent with the opinion of a majority of voters.

[17] In Prat's (2005) model, one realization of the signal is better news about the agent's type than the other (Prat calls it the "smart" realization), and the bad agent may choose the action corresponding to the "smart" realization rather than follow his true signal.

[18] Less closely related, hindsight bias interpretatively resembles political agency models in which external institutions (such as media or experts) are used (as an indoctrination device) to influence the perceived reputation of the government, see for example Besley and Prat (2006).

2 Basic model

In this section, we present a simple two-period political agency model. To model the effects of the strategic interaction between a decision maker (politician, agent) and a possibly biased evaluator (voter, principal) a binary state space, action space, signal space and outcome space is sufficient for our analysis. The model's fundamentals are introduced with rational voters, assumptions regarding hindsight biased voters (such as the biased information structure) are explained in section 4.

Information and timing

The politician is assumed to know his type $\theta \in \{\theta_L, \theta_H\}$, and the prior probability λ_I (I for the "incumbent") of being of high ability (θ_H) is common knowledge. The state of the world is $\omega \in \{0, 1\}$ with $\Pr(\omega = 0) = \pi \in (0, 1)$. Random variables ω and θ are independently distributed. Type θ_H politicians learn ω with certainty. Meanwhile, everybody, including type θ_L politicians and voters receive an imperfect signal $\sigma \in \{\sigma_0, \sigma_1\}$ about the state of the world. The distribution of this public signal conditional on ω is given in Table 1. The probability that the signal corresponds to the underlying state of nature is $x_0 \equiv Pr[\sigma_0|\omega = 0]$ and $x_1 \equiv Pr[\sigma_1|\omega = 1]$ respectively.

	σ_0	σ_1
$\omega = 0$	x_0	$1 - x_0$
$\omega = 1$	$1 - x_1$	x_1

Table 1: Distribution of the signal

There are two possible actions $a \in \{a_0, a_1\}$ from which the decision maker can choose. Policy a_0 is interpreted as maintaining the status quo and a_1 as implementing a reform. The policy outcome (consequence) is $y \in \{0, \Delta\}$. Status quo action a_0 always yields a payoff of 0 to society, while action a_1 costs c and delivers a payoff of Δ if $\omega = 1$, and 0 if $\omega = 0$. We assume $\Delta > c > 0$ so that a_1 yields a higher payoff than a_0 if and only if $\omega = 1$.

We impose the following assumption regarding the informativeness of the signal:

Assumption 1 *The distribution of σ satisfies*

$$\frac{x_0}{1 - x_1} > \frac{(1 - \pi)(\Delta - c)}{\pi c} > \frac{1 - x_0}{x_1}.$$

This assumption ensures that, given signal σ_ω, it is welfare maximizing to implement policy a_ω. Action a_0 is optimal after observing σ_0 if and only if

$$(1 - \nu_0)\Delta - c < 0,$$

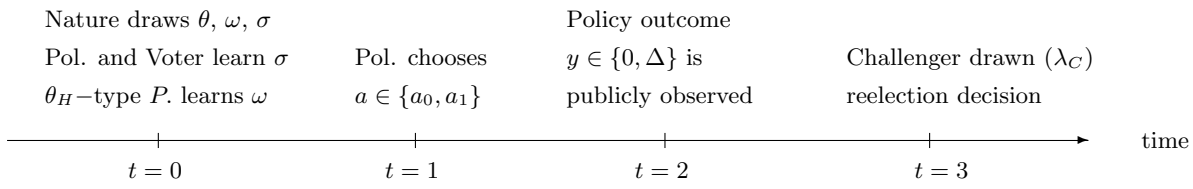

Figure 1: Timing of the game (term 1)

where $\nu_0 \equiv \Pr[\omega = 0|\sigma_0] = \frac{\pi x_0}{\pi x_0 + (1-\pi)(1-x_1)}$. Similarly, action a_1 is optimal after observing signal σ_1 if and only if

$$\nu_1 \Delta - c > 0,$$

where $\nu_1 \equiv \Pr[\omega = 1|\sigma_1] = \frac{(1-\pi)x_1}{(1-\pi)x_1 + \pi(1-x_0)}$. Both conditions are implied by Assumption 1. In what follows, we will most often use ν, the probability that the signal is correct (that the state of the world is the one indicated by the signal), rather than x. We will sometimes refer to ν as the precision of the signal.

The game is played in two periods which are interpreted as terms in office. Period 1 is divided into four stages, see figure 1. At date $t = 0$, nature draws the incumbent's type θ and the state of the world ω. All types of politicians and voters observe the public signal σ but only type θ_H politicians learn the state of the world ω. At $t = 1$, the incumbent decides which action to implement. At date $t = 2$, the outcome of the policy is realized and learnt by all players. At date $t = 3$, the final stage of period 1, a challenger is drawn. The probability that the challenger is of high ability is $\lambda_C \in [0, 1]$, drawn from a uniform distribution. Voters learn λ_C and then choose between incumbent and challenger in the election.[19] In the second period, following the draw of ω the appointed politician takes an action. After that, second period outcome is realized and publicly observed. Then, the game ends.

Politicians and voters

Voters' task is to decide whether to reelect or replace the incumbent. Their strategy consists of a probability distribution over the actions "reelect the incumbent" and "elect the challenger" for each possible combination of signal about the state of nature, observed action, realized outcome, and the challenger's perceived ability. The voter's payoff equals expected

[19] For simplicity we assume a representative voter in the sense of a pivotal median voter. This assumption implies that politicians act as if confronted with homogeneous voters' beliefs, that is all voters hold the same beliefs about the government. Alternatively, the setup might be interpreted as representing an electorate with three groups of voters: two equally strong partisan groups which always vote for their party's candidate, and a third group of "independent voters" who vote for the candidate which they perceive as more competent, regardless of his affiliation.

social welfare. The politician's preferences are given by

$$u = \phi W + (1 - \phi) \Pr[\text{reelection}],$$

where W is social welfare and $\phi \in [0, 1]$ a weighting factor that determines a politician's relative concerns for welfare an reelection.[20] Since there are no reelection concerns in the second term, the politician's objective is perfectly aligned with the voters'. Thus all politicians *try to maximize* welfare in the second term but are not all equally good at it. The voters' optimal strategy is therefore to elect the candidate they perceive as more competent. Let $\mu(\sigma, a, y)$ denote voters' posterior belief that the politician is of type θ_H given the recalled signal σ, the policy choice a and the realized outcome y.[21] We will sometimes refer to μ as the incumbent's reputation. The optimal strategy for a voter is to reelect the incumbent if and only if $\lambda_C \leq \mu(\sigma, a, y)$. Since we have assumed that λ_C is uniformly distributed on $[0, 1]$, the probability that the incumbent is reelected is equal to the voter's posterior belief that he is of high ability.

The politician's payoff is given by his expected utility denoted $U(\cdot)$. Let α denote a mixed action such that the politician plays a_0 with probability α and a_1 with probability $1 - \alpha$. Hence, expected utility given the voters' behavior and the information available to the politician is

$$U(\alpha, \mu, \Psi_\theta) = \alpha(1 - \phi)\mu(\sigma, a_0, 0) + (1 - \alpha)\big[\phi E(W|\Psi_\theta) + (1 - \phi)E\big(\mu(\sigma, a_1, y)|\Psi_\theta\big)\big],$$

where Ψ_θ is the politician's (type dependent) information set is given by

$$\Psi_\theta = \begin{cases} (\omega, \sigma) & \text{for} \quad \theta = \theta_H \\ \sigma & \text{for} \quad \theta = \theta_L. \end{cases}$$

A strategy for the politician prescribes a probability $s(\theta, \Psi_\theta)$ of playing a_0 for each type θ and for each possible realization of the information Ψ_θ.[22] We can now define the equilibrium of the game. In the definition below, the voter's strategy is omitted because of its simplicity.

Definition 1 *A PBE of this game is such that* (i) *strategies are optimal given beliefs, i.e.*

$$\forall\, \theta, \forall\, \Psi_\theta, \quad s^*(\theta, \Psi_\theta) \in \arg\max_\alpha\, U(\alpha, \mu, \Psi_\theta)$$

[20] We assume that all players are risk neutral.

[21] For rational voters the recollected signal σ always coincides with the original signal.

[22] In game-theoretic terms, there are, strictly speaking, two independent subgames, and *three* types of politician in this model: one subgame for each realization of the signal (σ_0 and σ_1), two types of high-ability politician, one for each realization of ω, and one type of low-ability politician. We have chosen to label the types in more intuitive terms for greater clarity of exposition.

and (ii) *beliefs are derived from equilibrium strategies and observed actions using Bayes' rule, i.e.*

$$\mu(\sigma, a, y) = \frac{\lambda_I \Pr[\sigma, a, y|\theta_H]}{\lambda_I \Pr[\sigma, a, y|\theta_H] + (1-\lambda_I)\Pr[\sigma, a, y|\theta_L]}.$$

We will drop the politician's type from the specification of strategies as this cannot lead to confusion. Thus, we will write $s(\omega, \sigma)$ instead of $s(\theta_H, (\omega, \sigma))$ and $s(\sigma)$ instead of $s(\theta_L, \sigma)$. In terms of equilibrium characterization, we look for an equilibrium where the high-ability politician always implements the policy that maximizes welfare, that is, he chooses the policy that corresponds to the state of nature. Formally, the strategy $s(0, \sigma) = 1$ and $s(1, \sigma) = 0$, regardless of σ, is sometimes referred to as mechanical strategy. We will then show that this is indeed optimal for him in equilibrium, given voters' beliefs.[23]

In the next sections, we establish a perfect Bayesian equilibrium (PBE) of the specified game under the assumption of perfect rationality on the part of all players and thereafter extend the analysis to the case of hindsight-biased voters.[24]

3 Equilibrium with rational voters

With rational voters, the game has two independent subgames, one for each realization of the signal σ, which we will analyze subsequently.

The σ_0 subgame

Assume $\sigma = \sigma_0$, that is, the signal indicates that the state of the world $\omega = 0$, and thus that policy a_0 is optimal for welfare. We start by specifying voters' posterior beliefs about the politician's type given an observed triplet (σ_0, a, y) and the low type's strategy $s(\sigma_0)$. Figure 2 shows all possible events that can arise and how to get there, using the fact that the high type plays mechanically (as explained at end of section 2).

Applying Bayes' rule, we have, for any $0 \leq s(\sigma_0) < 1$,

$$\begin{aligned}
\mu(\sigma_0, a_0, 0) &= \frac{\lambda_I}{\lambda_I + (1-\lambda_I)s(\sigma_0))/\nu_0} \\
\mu(\sigma_0, a_1, 0) &= 0 \\
\mu(\sigma_0, a_1, \Delta) &= \frac{\lambda_I}{\lambda_I + (1-\lambda_I)\big(1 - s(\sigma_0)\big)}.
\end{aligned}$$

[23] There are other candidate equilibria, namely, pooling equilibria where both types of politician pool on one action (either a_0 or a_1) independent of their information, and voters attach pessimistic beliefs to deviations. In Appendix B, we demonstrate that these equilibria can be eliminated using the D1 criterion.

[24] We defer the definition of what we mean by hindsight bias in this model to that point.

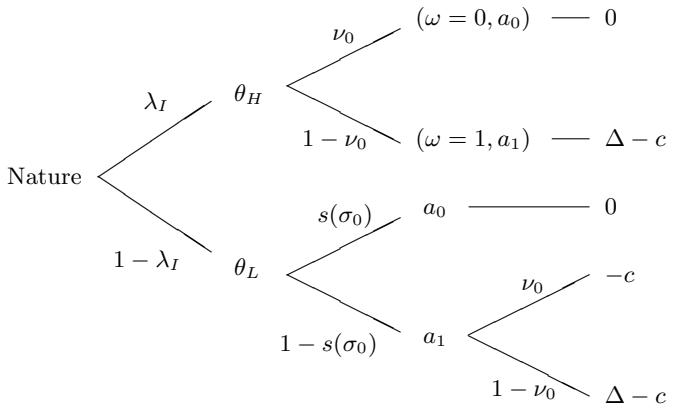

Figure 2: Game tree for the σ_0 subgame

If $s(\sigma_0)=1$, observing $(\sigma_0,a_1,0)$ is an out-of-equilibrium event for which Bayes' rule does not pin down voters' beliefs. We will assume, however, that voters have pessimistic beliefs, that is, $\mu(\sigma_0,a_1,0)=0$ for any $s(\sigma_0)$.[25]

Denote a low-ability politician's expected utility from playing a_0 by U_0^0, where the superscript stands for the signal σ and the subscript for the chosen policy action a. We have

$$\begin{aligned} U_0^0 &= \phi\cdot 0+(1-\phi)\cdot\mu(\sigma_0,a_0,0) \\ &= (1-\phi)\frac{\lambda_I}{\lambda_I+(1-\lambda_I)s(\sigma_0)/\nu_0}. \end{aligned} \tag{1}$$

Meanwhile, playing a_1 yields U_1^0 given by

$$\begin{aligned} U_1^0 &= \phi\big[(1-\nu_0)\Delta-c\big]+(1-\phi)\Big[\nu_0\,\mu(\sigma_0,a_1,0)+(1-\nu_0)\,\mu(\sigma_0,a_1,\Delta)\Big] \\ &= \phi\big[(1-\nu_0)\Delta-c\big]+(1-\phi)\frac{(1-\nu_0)\lambda_I}{\lambda_I+(1-\lambda_I)\big(1-s(\sigma_0)\big)}. \end{aligned} \tag{2}$$

We will categorize equilibria according to the low type's equilibrium strategy: when $s(\sigma_0)=1$, we will talk about pure-strategy equilibrium, while for $0<s(\sigma_0)<1$ (the low type randomizes between a_0 and a_1), we will talk about mixed-strategy equilibrium.[26] For a pure-strategy equilibrium, it must be the case that the low-ability politician prefers a_0 over a_1 even if voters believe that $s(\sigma_0)=1$, i.e. voters think that any politician who chooses a_1 and

[25] This seems quite natural, not least since it is exactly the belief Bayes' rule specifies for any $s(\sigma_0)<1$. The refinement is not crucial for the qualitative results in this section.

[26] An equilibrium where the high type always chooses the policy corresponding to the underlying state of nature and the low type always does the opposite of what the signal suggests can be ruled out. To see why, note first that in this kind of equilibrium, voters believe that any politician who *does* follow the signal must be of high ability. Thus, the low type can increase his reputation by choosing the policy the signal suggests. Moreover, in terms of expected social welfare, the low type is always better off following the signal. Therefore, choosing the "wrong" policy all the time cannot be an equilibrium.

succeeds must be of high type. In that case, the low type could fool voters into thinking he is of high ability by implementing a successful reform. If, despite such beliefs, we have $U_0^0 \geq U_1^0$, then we are in a pure-strategy equilibrium.[27] Otherwise, we are in a mixed-strategy equilibrium where the high type always chooses the "right" policy while the low type randomizes between actions a_0 and a_1. In order for him to be willing to do so, he must be indifferent between the two policies, that is, both must procure him equal utility in expectation. This requires that voters hold the appropriate beliefs. More precisely, voters beliefs must be such that $U_0^0 = U_1^0$. Lemma 1 characterizes the conditions under which these equilibria obtain.

Lemma 1 *Suppose voters are rational and that* $\lambda_I < \frac{c\Delta}{(\Delta-c)^2+c\Delta}$. *Then, there exists a threshold* $\nu_0^R \in (1-c/\Delta, 1)$ *for the* σ_0 *subgame, defined by*

$$\phi\big[(1-\nu_0^R)\Delta - c\big] = (1-\phi)\left[\frac{\lambda_I}{\lambda_I + (1-\lambda_I)/\nu_0^R} - (1-\nu_0^R)\right], \tag{3}$$

that characterizes an equilibrium with the following properties: the high-ability politician chooses a_0 *when* $\omega = 0$ *and* a_1 *when* $\omega = 1$, *while the low-ability politician always chooses* a_0 *when* $\nu_0 \geq \nu_0^R$ *and randomizes between* a_0 *and* a_1 *when* $\nu_0 < \nu_0^R$. *In the latter case, type* θ_L*'s equilibrium probability of playing* a_0, $s_R^*(\sigma_0)$, *is determined by*

$$(1-\phi)\frac{\lambda_I}{\lambda_I + (1-\lambda_I)s_R^*(\sigma_0)/\nu_0} = \phi\big[(1-\nu_0)\Delta - c\big] + (1-\phi)\frac{(1-\nu_0)\,\lambda_I}{\lambda_I + (1-\lambda_I)\big(1-s_R^*(\sigma_0)\big)}, \tag{4}$$

and $s_R^*(\sigma_0)$ *increases with* ν_0.

Thus, under some conditions on parameters, there is a threshold value of signal precision above which we are in a pure-strategy equilibrium where the low type always follows the public signal, and below which we are in a mixed-strategy equilibrium where the low type randomizes. In the mixed-strategy case, the equilibrium probability of playing a_0 increases with the signal precision.

The assumption $\lambda_I < \frac{c\Delta}{(\Delta-c)^2+c\Delta}$ says that the prior probability of the politician being of high ability cannot be too large. Otherwise, the politician's reputation from implementing a_0 is so large that gambling on a_1 is never worthwhile, even when the signal is of low precision. Hence, if this assumption is violated, the politician always follows his signal, regardless of its quality; there is never any randomization by the low type. Furthermore, the threshold interval used in the equilibrium characterization is implied by the signal informativeness, see assumption 1.

[27] Technically, it would be inappropriate to talk about a separating equilibrium since from a game-theoretic point of view, the model has three types; see footnote 22. The two high-ability types play pure strategies corresponding to the state of nature. Hence, whatever the action the low type plays, he always "pools" with one of the two high types.

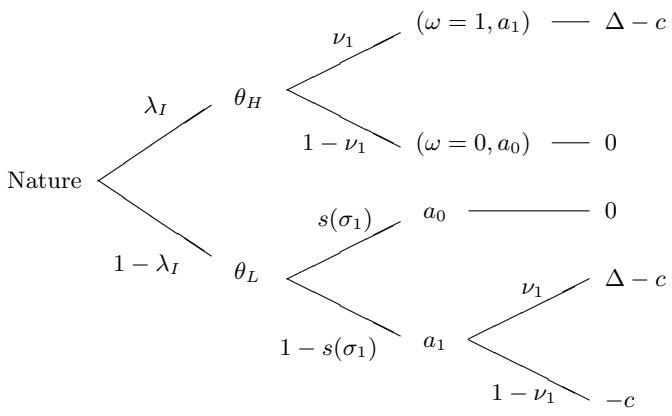

Figure 3: Game tree for the σ_1 subgame

The σ_1 subgame

Now assume that $\sigma = \sigma_1$, suggesting that a reform should be implemented. Figure 3 again facilitates the calculation of posterior beliefs, which are now given by

$$\begin{aligned}
\mu(\sigma_1, a_0, 0) &= \frac{\lambda_I}{\lambda_I + (1-\lambda_I)s(\sigma_1)/(1-\nu_1)} \\
\mu(\sigma_1, a_1, 0) &= 0 \\
\mu(\sigma_1, a_1, \Delta) &= \frac{\lambda_I}{\lambda_I + (1-\lambda_I)\big(1-s(\sigma_1)\big)}.
\end{aligned}$$

When the low-ability politician plays a_1, his expected utility therefore is

$$\begin{aligned}
U_1^1 &= \phi(\nu_1\Delta - c) + (1-\phi)\Big[(1-\nu_1)\mu(\sigma_1, a_1, 0) + \nu_1\,\mu(\sigma_1, a_1, \Delta)\Big] \\
&= \phi(\nu_1\Delta - c) + (1-\phi)\frac{\nu_1\lambda_I}{\lambda_I + (1-\lambda_I)\big(1-s(\sigma_1)\big)}. \qquad (5)
\end{aligned}$$

Meanwhile, playing a_0 would procure him utility

$$\begin{aligned}
U_0^1 &= (1-\phi)\mu(\sigma_1, a_0, 0) \\
&= (1-\phi)\frac{\lambda_I}{\lambda_I + (1-\lambda_I)s(\sigma_1)/(1-\nu_1)}. \qquad (6)
\end{aligned}$$

Lemma 2 describes the equilibrium in the σ_1 subgame, it is similar to the one in the σ_0 subgame.

Lemma 2 *Suppose voters are rational and that $\lambda_I > 1 - \frac{\phi(\Delta-c)}{1-\phi}$. Then, there exists a threshold $\nu_1^R \in (c/\Delta, 1)$ for the σ_1 subgame, defined by*

$$\phi(\nu_1^R\Delta - c) = (1-\phi)\left[1 - \nu_1^R\lambda_I\right],$$

that characterizes an equilibrium with the following properties: the high-ability politician chooses a_0 when $\omega = 0$ and a_1 when $\omega = 1$, while the low-ability politician always chooses a_1 when $\nu_1 \geq \nu_1^R$ and randomizes between a_0 and a_1 when $\nu_1 < \nu_1^R$. In the latter case, type θ_L's equilibrium probability of playing a_0, $s_R^*(\sigma_1)$, is determined by

$$(1-\phi)\frac{\lambda_I}{\lambda_I + (1-\lambda_I)s_R^*(\sigma_1)/(1-\nu_1)} = \phi(\nu_1\Delta - c) + (1-\phi)\frac{\nu_1\,\lambda_I}{\lambda_I + (1-\lambda_I)\big(1-s_R^*(\sigma_1)\big)}, \quad (7)$$

and $s_R^*(\sigma_1)$ decreases with ν_1.

Like in the σ_0 subgame, the equilibrium of the σ_1 subgame has the low-ability politician randomizing for low values of signal precision, and always following the public signal for high values of precision. If the assumption $\lambda_I > 1 - \frac{\phi(\Delta - c)}{1-\phi}$ is not satisfied, the signal is never sufficiently precise to induce a pure-strategy, even when ν_1 is arbitrarily close to 1. Reelection concerns are so strong that the low-ability politician randomizes whatever the quality of his signal. Figure 4 depicts the low type's equilibrium strategy as a function of the signal precision for both subgames.

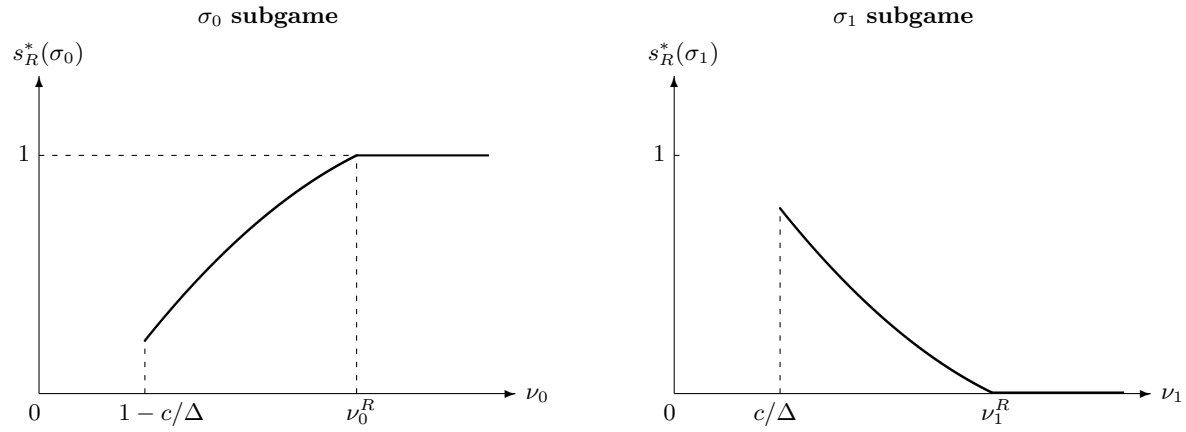

Figure 4: Equilibrium strategies for type θ_L with rational voters

Corollary 1 *The probability that type θ_L plays a_0 (a_1) is strictly greater (smaller) after receiving signal σ_0 than after receiving signal σ_1: $s_R^*(\sigma_0) > s_R^*(\sigma_1)$.*

This follows directly from Assumption 1 (which implies that $\nu_1 > 1 - \nu_0$) and the monotonicity properties of the equilibrium strategies, noting that $s_R^*(\sigma_0)$ would equal $s_R^*(\sigma_1)$ if $\nu_1 = 1 - \nu_0$.

4 Hindsight bias as a discipline device

Voters are hindsight biased if the recollection of the prior probability they hold about the state of the world diverges from their original prior once they have learned new information about which state of the world truly prevails.[28] This means hindsight biased evaluators are unable to ignore their additional information when trying to recall their original judgment. The bias can be formulated by using conditional expectations, as follows,

$$E[E(\omega|\sigma)|\sigma, a, y] = bE(\omega|\sigma, a, y) + (1-b)E(\omega|\sigma),$$

where $b \in [0,1]$ measures the degree of hindsight bias.[29] The bias translates into a violation of the law of iterated expectations and as a result the recalled prior belief regarding ω is located somewhere between the true prior and the posterior probability. However, in the binary model, there are only two possible priors, one for each realization of the signal: $E(\omega|\sigma_0) = 1-\nu_0$ and $E(\omega|\sigma_1) = \nu_1$. Without restrictions on b, an evaluator's set of recalled prior probabilities would be different from the set possible original prior probabilities. We therefore choose a formulation of hindsight bias that is consistent with the set of prior beliefs a biased (or rational) evaluator may originally hold about the state of the world.

Definition 2 (Hindsight bias with a binary signal) *Hindsight biased voters overestimate the accuracy of their prior belief about the state of the world: If $\sigma = \sigma_0$ and they learn that $\omega = 1$, they think that ex ante they attached probability ν_1 to the state of the world being 1 even though their original signal suggested probability $1-\nu_0 < \nu_1$. Thus, they erroneously believe that the signal was σ_1 rather than σ_0. Similarly, if $\sigma = \sigma_1$ and they learn that $\omega = 0$, hindsight biased voters think that their prior was ν_0 even when according to their signal it was $1-\nu_1 < \nu_0$; they think that their signal was σ_0 rather than σ_1.*

The bias alters a voter's *recalled prior* in direction of the actually observed outcome. The status quo policy a_0 is uninformative for voters in terms of its outcome.[30] For hindsight biased voters, the recollection of prior probabilities is only altered when new information about the state of the world is revealed, i.e. when the reform policy a_1 is implemented. After policy a_1, voters learn the state of the world with certainty: posterior beliefs over ω are $E(\omega|\sigma, a_1, \Delta) = 1$ and $E(\omega|\sigma, a_1, 0) = 0$.[31] Table 2 summarizes a biased voter's recalled signal as a function of outcome y. Due to our binary model, the definition of hindsight

[28] Consult section 4.2 for details on the psychological foundation of the bias.

[29] See Camerer *et al.* (1989) or Biais and Weber (2006).

[30] A status quo action a_0 always leads to outcome $y = 0$ and in this case signals are not distorted by hindsight biased evaluators because $E(\omega|\sigma_0, a_0, 0) = E(\omega|\sigma_0)$ and $E(\omega|\sigma_1, a_0, 0) = E(\omega|\sigma_1)$.

[31] We can then identify the parameter b which implicitly underlies our setup as $\nu_1 = b\cdot 1 + (1-b)(1-\nu_0) \iff b = (\nu_1 + \nu_0 - 1)/\nu_0$ in the σ_0 subgame, and $1-\nu_0 = b\cdot 0 + (1-b)\nu_1 \iff b = (\nu_1 + \nu_0 - 1)/\nu_1$ in the σ_1

	Original signal	
(after a_1)	$\sigma = \sigma_0$	$\sigma = \sigma_1$
$y = 0$	σ_0	σ_0
$y = \Delta$	σ_1	σ_1

Table 2: Biased recollection of original signal σ

bias leads to an extreme form of bias since the recalled signal changes from σ_0 to σ_1 (and vice versa) with probability one.[32] In solving for the equilibrium of the game with hindsight biased voters we maintain the concept of PBE to the extent possible. For this we assume that politicians anticipate the voters' hindsight bias, and that voters can compute the politician's equilibrium strategy. To solve the game with biased voters, one generally has to consider each of the two subgames σ_0 and σ_1. It however turns out that the σ_1 subgame with biased voters is equivalent to the σ_1 subgame with rational voters. In case of a failed reform, hindsight bias changes an evaluator's posterior belief from $\mu(\sigma_1, a_1, 0)$ to $\mu^B(\sigma_1, a_1, 0) = \mu(\sigma_0, a_1, 0)$, that is he misinterprets the original signal. But these posteriors are both equal to zero, whatever the low type's equilibrium strategy, because of the assumption of pessimistic beliefs. Therefore, when $\sigma = \sigma_1$, the hindsight biased equilibrium strategies, $s^*_B(\sigma_1)$ for the low type and $s^*_B(\omega, \sigma_1)$ for the high type, are the same as in the equilibrium with rational voters, see Lemma 2.[33] This only leaves the subgame following signal σ_0 to be analyzed.

Unlike in the rational case, the σ_0 subgame under biased evaluation is however not independent of the σ_1 subgame. This is because the evaluator calculates his posterior about the politician's type with a biased prior probability. As will become clear, posterior beliefs – and hence, equilibrium strategies – in the σ_0 subgame depend on the equilibrium strategy $s^*_R(\sigma_1)$ of the σ_1 subgame.[34] Thus, when deriving the equilibrium of the σ_0 subgame, one generally has to consider all possible equilibria that may arise in the σ_1 subgame.

4.1 Equilibrium with biased voters

Assume $\sigma = \sigma_0$, so the signal implies (by assumption 1) that the status quo action a_0 is optimal in terms of welfare. The voters' posterior beliefs about the politician's type depend on the observed event (σ_0, a, y), the low type's strategy $s(\sigma_0)$, and the high type's mechanical

subgame.

[32] In section 4.2 we discuss different assumptions concerning own bias awareness and its implications.

[33] In other words, equilibrium strategies in the σ_1 subgame are $s^*_B(\sigma_1) = s^*_R(\sigma_1)$ for a low type and $s^*_B(\omega, \sigma_1) = s^*_R(\omega, \sigma_1)$ for a high type.

[34] Note the reverse is not true since the σ_1 subgame is unaffected by hindsight bias, as mentioned above.

strategy.[35] By Bayes' rule and the assumption of pessimistic beliefs, a biased voter's posterior beliefs, for any $0 \leq s(\sigma_0) \leq 1$, are,[36]

$$\begin{aligned} \mu(\sigma_0, a_0, 0) &= \frac{\lambda_I}{\lambda_I + (1-\lambda_I)s(\sigma_0)/\nu_0} \\ \mu(\sigma_0, a_1, 0) &= 0 \\ \mu^B(\sigma_0, a_1, \Delta) = \mu(\sigma_1, a_1, \Delta) &= \frac{\lambda_I}{\lambda_I + (1-\lambda_I)(1-s_R^*(\sigma_1))}. \end{aligned}$$

The effects of hindsight bias come directly into play at the posterior belief for event (σ_0, a_1, Δ). Upon observing outcome $y = \Delta$, biased voters learn that the state of the world is $\omega = 1$, and distort their recollection of the prior belief, which was based on the original signal σ_0, towards their ex post information by wrongly believing that the signal had been σ_1, and hence $\mu^B(\sigma_0, a_1, \Delta) = \mu(\sigma_1, a_1, \Delta)$.

The expected utility for the θ_L type if he plays action a_0 is,

$$U_0^0 = \phi \cdot 0 + (1-\phi) \cdot \mu(\sigma_0, a_0, 0), \tag{8}$$

while the expected utility from deviating action a_1 yields,

$$U_1^0 = \phi\big[(1-\nu_0)\Delta - c\big] + (1-\phi)\big[\nu_0\, \mu(\sigma_0, a_1, 0) + (1-\nu_0)\, \mu^B(\sigma_0, a_1, \Delta)\big]. \tag{9}$$

For a pure strategy equilibrium, a θ_L type must prefer a_0 over a_1 such that $U_0^0 \geq U_1^0$ even if voters belief $s(\sigma_0) = 1$. Otherwise we are in a mixed-strategy equilibrium where the low type randomizes between pure actions such that $U_0^0 = U_1^0$, given appropriate beliefs of voters. Lemma 3 describes the equilibrium behavior with hindsight biased voters in the σ_0 subgame.

Lemma 3 *Suppose voters are hindsight biased and* $\lambda_I < \frac{(\Delta - c)\Delta s_R^*(\sigma_1) + 2c\Delta - \Delta^2}{(\Delta - c)\Delta s_R^*(\sigma_1) + c^2}$. *Then, there exists a threshold* $\nu_0^B \in (1 - c/\Delta, 1)$ *for the* σ_0 *subgame, defined by*

$$\phi\big[(1-\nu_0^B)\Delta - c\big] = (1-\phi)\left[\frac{\lambda_I}{\lambda_I + (1-\lambda_I)/\nu_0^B} - \frac{(1-\nu_0^B)\lambda_I}{\lambda_I + (1-\lambda_I)(1-s_R^*(\sigma_1))}\right], \tag{10}$$

that characterizes an equilibrium with the following properties: the high-ability politician chooses a_0 *when* $\omega = 0$ *and* a_1 *when* $\omega = 1$, *while the low-ability politician always chooses* a_0 *when* $\nu_0 \geq \nu_0^B$ *and randomizes between* a_0 *and* a_1 *when* $\nu_0 < \nu_0^B$. *In the latter case, type* θ_L*'s equilibrium probability of playing* a_0, $s_B^*(\sigma_0)$, *is determined by*

$$\frac{\lambda_I}{\lambda_I + (1-\lambda_I)s_B^*(\sigma_0)/\nu_0} = \frac{\phi}{(1-\phi)}\big[(1-\nu_0)\Delta - c\big] + \frac{(1-\nu_0)\,\lambda_I}{\lambda_I + (1-\lambda_I)\big(1 - s_R^*(\sigma_1)\big)}, \tag{11}$$

and $s_B^*(\sigma_0)$ *increases in* ν_0.

[35] As in the equilibrium candidates with rational voters, a high ability politician's equilibrium strategy is $s(\omega = 0, \sigma) = 1$ and $s(\omega = 1, \sigma) = 0$, $\forall \sigma$. Type θ_H always chooses the optimal policy, given the state of the world.

[36] Note that for $s(\sigma_0) = 1$, the posterior belief for the then out-of-equilibrium event $(\sigma_0, a_1, 0)$ is not defined by Bayes' rule. We therefore assume, as in the rational section, pessimistic beliefs for this event such that $\mu(\sigma_0, a_1, 0) = 0$, $\forall\ s(\sigma_0)$.

To see the impact of hindsight biased evaluation, consider the case of a pure strategy equilibrium defined in the lemma above. Due to the biased memory technology, a voter's hindsight bias reduces the low-ability politician's incentives to deviate. While in the rational case, a politician's reputation from achieving outcome Δ despite signal σ_0 is equal to 1, it is strictly lower in the hindsight biased case. This is because a biased voter considers the outcome $y = \Delta$ in retrospect more predictable than it actually was. Ex post he thinks that $\omega = 1$ had been more likely ex ante than was truly the case, and thus wrongly believes that playing a_1 was an obvious choice that even the low type should have made with strictly positive probability (given by $1 - s_R^*(\sigma_1)$).

We are now able to assess whether hindsight bias improves the low-ability politician's decision making. The next proposition states our main result regarding discipline.

Proposition 1 *Assume* $\lambda_I < \frac{c\Delta}{(\Delta-c)^2+c\Delta}$. *Then, for any* $\nu_0 < \nu_0^R$, *hindsight bias strictly improves the low-ability politician's discipline:* $s_B^*(\sigma_0) > s_R^*(\sigma_0)$.

Proposition 1 means that, in terms of first-period social welfare, voters may benefit from being hindsight biased. Anticipating the voters' bias, the low-ability politician knows that he has relatively little to gain from deviating to a reform policy, and accordingly, will do so less often. The intuition for this result is the following. We know that the low type is always more likely to play reform after observing σ_1 than after σ_0. When in face of signal σ_0, the politician chooses reform a_1 and succeeds, hindsight biased voters change their recollection of the signal to σ_1, and thus believe that the low type should have played reform with a higher probability than was actually the case (given σ_0). As a result, voters exaggerate the likelihood that the observed event came from a low type, which reduces their esteem for the incumbent. For the low-ability politician, deviation is therefore associated with diminished reelection prospects compared to the rational voter case.

In Figure 5, equilibrium strategies for a low-ability decision maker in the σ_0 subgame under rational and biased evaluation are compared. The threshold value of signal precision required for a pure strategy equilibrium is lower when voters are hindsight biased (ν_0^B) than when they are fully rational (ν_0^R). Because voters that suffer from the bias are less easily impressed by deviating behavior (if successful, they think they saw it coming), the low-ability politician's incentives to play a_1, when the signal suggests the opposite (σ_0), are diminished. Thus, the signal precision required for him to be disciplined and follow the signal is smaller than under fully rational evaluation.

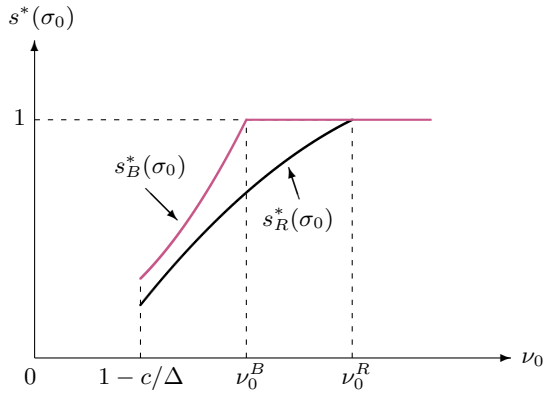

Figure 5: Rational and biased equilibrium strategies for type θ_L

4.2 Discussion

We discuss the psychological foundation of hindsight bias and then look at players' bias awareness and its implications.

Bias and imperfect memory

Hindsight bias characterizes a systematic way in which the evaluator's judgment about the likelihood of an event departs from perfect rationality, or as Rabin (1998, p. 30) puts it, "people exaggerate the degree to which their beliefs before an informative event would be similar to their current beliefs." For the problem we study this means that after the evaluator observes the outcome, he overestimates the extent to which the realized event was foreseeable. A hindsight biased voter who judges the quality of the politician's decision violates basic decision making principles because in constructing a (biased) prior he mistakenly incorporates information into his evaluation that was only known after the date of decision. In judgments of decisions under uncertainty, the bias therefore blurs the two major elements he initially set out to distinguish in his evaluation, namely skill and luck of the decision maker. Being more specific, the bias in our model leads the evaluator to confuse decision and outcome quality.

In general, judgment biases are explained in psychology by motivational or cognitive theories. Motivational theories rationalize the existence of a judgment bias by a deliberate but often subconscious choice of the decision maker inasmuch as he may derive a (psychological) benefit from it.[37] In cognitive theories, meanwhile, hindsight bias is attributed to information

[37] Motivated self-presentation influences an individual's estimation of the original ex ante prior because the individual derives a benefit from appearing smart in front of others or himself. Motivational theories rationalize self-serving biases, but those biases are not restricted to self-image concerns. Hindsight bias can also be caused by affective or motivational suppression of changes in probability assessments over time because it decreases an individual's perception of uncertainty in the world.

processing effects. Since memory and reasoning is often affected by motivation, the judgment bias generally referred to as hindsight bias may be reinforced by motivational aspects but recent research in psychology seems to identify cognitive effects as the main source of this bias.[38]

In the political agency model we consider, an evaluator does not judge the quality of own past decisions but past decisions of others. Hence an important dimension of self-signaling (for example to justify own past decisions) does not apply in our framework. The only motivated self-signaling possible is, for the evaluator, to think he would have been a better decision maker then the one he is supposed to judge. We assume that such self-serving effects play no role for voters in our problem and rather define hindsight bias as a by-product of knowledge updating after outcome information has been received.[39] Under the bounded rationality assumption on prior probabilities (imperfect recall), a subject has to follow some mental strategy to *reconstruct* the original prior from the default (ex post) information which he holds now; this is what Hawkins and Hastie (1990) call "reconstruction of the prior judgment by 'rejudging' the outcome". Thus, a biased evaluator's default memory consists of current, up to date probability estimates but does not always stock all ex ante formed prior probabilities because new information partly destroys or reduces their accessibility, as shown in section 4.[40] As a consequence, the imperfect recollection process also hinders conscious learning, conscious in the sense that the evaluator is not aware of the revised probability assessment concerning the state of the world. This (purely cognitive) bounded memory has a strong self-manipulating effect because it implies a reduction of surprises of any kind.

Awareness

A boundedly rational (or imperfect) memory also challenges standard solution concepts. To satisfy the conditions required for a PBE, we assume that politicians anticipate the voters' hindsight bias and that voters are aware of their hindsight bias *ex ante* in order to correctly infer the politician's equilibrium strategy. Voters' beliefs are based on the politician's strategy, which they correctly anticipate. They are derived from the equilibrium strategy that the voters think the politician has used given the signal they recall. Thus voters may hold incorrect posterior beliefs, but the mistake stems solely from the erroneous recollection of the

[38] Also consult Hoffrage *et al.* (2000) for a cognitive hindsight bias theory based on imperfect memory.

[39] Alternatively, the bias design could also include the assumption of motivated cognition as in Bénabou and Tirole (2006) or Levy (2007), which would give the evaluator an opportunity for memory manipulation, or (motivated) manipulation of own beliefs about the world.

[40] Hoffrage *et al.* (2000) favor cognitive memory theories with respect to hindsight bias. They emphasize the fact that for subjects with capacity-constrained memory, holding current information in memory is, for general tasks, more important and accurate than remembering past prior probabilities which are, by definition, based on outdated information. For somewhat related memory-based models of bounded rationality in economic theory see Mullainathan (2002) and the literature cited therein.

prior and not from wrong expectations about strategies. In other words, we suppose that voters are *sophisticated* ex ante, but *naive* ex post because they are not aware that their memorized signal may be distorted. While this psychological inconsistency assumption may seem strong, it is in line with recent experimental and empirical studies.[41] From a theoretical perspective, our model of ex post naive voters resembles the memory model of Mullainathan (2002), there a decision maker also takes the recalled history of signals as the true history. A similar assumption is made in Cremer *et al.* (2007) where myopic agents vote over public pensions. In their model, agents are assumed to be aware of their myopia (lack of self-control) at the voting stage. Nevertheless, they cannot avoid it later on when making consumption decisions.

Alternative awareness assumptions are conceivable. Suppose voters are ex post sophisticated, i.e. they are aware at the voting stage that their recollection may be distorted due to hindsight bias.[42] Then, instead of naively changing signals, evaluators act ex post rationally by forming an expectation over the set of possible ex ante signals. In case of a successful reform and with the ex post probability weight β for original signal σ_0, a voter's belief is then $\beta\ \mu(\sigma_0, a_1, \Delta) + (1-\beta)\ \mu(\sigma_1, a_1, \Delta)$. The conclusion we have drawn for hindsight biased evaluation above remains valid for any $\beta < 1$. Yet the effects of hindsight bias if voters are fully (ex ante and ex post) naive are difficult to assess using PBE because then convergence of beliefs and strategies is not guaranteed. Therefore, under the assumption of full naïveté, other solution concepts are called for.

5 Selection and welfare

Proposition 1 shows that hindsight bias improves the discipline of the (low-ability) incumbent. Therefore, the effect of hindsight bias on voters' first-period welfare is unambiguously positive. To make a general statement about the welfare consequences of hindsight bias, however, we must also take into account second-period welfare. This means we have to investigate the effect on selection: Because in the second period, the politician always implements the policy that, according to the information he possesses, is best, voters are always weakly better off in the second period if a high-ability politician is in office.

The effect of hindsight bias on selection works through two channels. The first is that voters sometimes have erroneous posteriors, so that they don't always elect the politician that

[41] For example, in Biais and Weber (2006) experts are informed about the potential effects of judgments in hindsight before the experiment took place, but even then subjects were unable to avoid hindsight biased judgments. In an empirical study, DellaVigna and Kaplan (2007) show that even voters who are aware of biased media coverage on television do not fully subtract the broadcaster's political bias in their voting decision.

[42] For a model where individuals forget or repress information, but are aware of the deficiencies of their memory, see Bénabou and Tirole (2002).

is truly more able (in expected terms). The second is more indirect: since the anticipation of voters' hindsight bias changes the low-ability politician's behavior, the inferences that can be drawn from a given event are modified too.

While the first effect clearly is bad for welfare, the second is more complex. Hindsight bias increases the low type's equilibrium probability of playing a_0 after receiving σ_0. This decreases the posterior probability of a high type after observing a_0, while the posterior probability of a high type after observing (a_1, Δ) increases. The net effect this has on sorting is *a priori* unclear.

In this section, we examine the reelection chances for each type of politician (low-ability and high-ability). Obviously, second-period welfare is higher if, *ceteris paribus*, high types are reelected more often and low types less often. Making a clear welfare statement would require that we show for example that hindsight bias improves the reelection chances of the high-ability politician while hurting those of the low-ability one. It turns out, however, that both effects do not point in the "right direction" so that we are unable to make such a statement. Indeed, we find that the impact of hindsight bias on selection is ambiguous.

First, we compare the posterior beliefs held by rational and hindsight biased voters in the σ_0 subgame upon observing an action and an outcome. With a slight abuse of notation, we will write $\mu_0\big(s\big)$ for the voters' posterior belief that the politician is competent given that he chose a_0 and that the low-type's equilibrium strategy is s (thus, for example, $\mu_0\big(s_R^*(\sigma_0)\big) \equiv \frac{\lambda_I}{\lambda_I+(1-\lambda_I)s_R^*(\sigma_0)/\nu_0}$). Analogously, the posteriors for the cases $(a_1, 0)$ and (a_1, Δ) are denoted $\mu_{10}(s)$ and $\mu_{1\Delta}(s)$, respectively.

Lemma 4 *If $\nu_0 < \nu_0^R$, the following inequalities hold for the politician's reputation:*

$$\mu_0\big(s_R^*(\sigma_0)\big) \;>\; \mu_0\big(s_B^*(\sigma_0)\big) \tag{12}$$

$$\mu_{10}\big(s_R^*(\sigma_0)\big) \;=\; \mu_{10}\big(s_B^*(\sigma_0)\big) \;=\; 0 \tag{13}$$

$$\mu_{1\Delta}\big(s_R^*(\sigma_0)\big) \;>\; \mu_{1\Delta}\big(s_R^*(\sigma_1)\big). \tag{14}$$

Given Lemma 4, the analysis of the politician's reelection chances becomes straightforward. Consider first the θ_L-type politician. With rational voters, his *ex ante* probability of reelection when the signal is σ_0, which we denote $\mathcal{R}_L^R$, is given by

$$\mathcal{R}_L^R = s_R^*(\sigma_0)\,\mu_0\big(s_R^*(\sigma_0)\big) + (1 - s_R^*(\sigma_0))(1-\nu_0)\,\mu_{1\Delta}\big(s_R^*(\sigma_0)\big),$$

while in the case of hindsight biased voters, it is

$$\mathcal{R}_L^B = s_B^*(\sigma_0)\,\mu_0\big(s_B^*(\sigma_0)\big) + (1 - s_B^*(\sigma_0))(1-\nu_0)\,\mu_{1\Delta}\big(s_R^*(\sigma_1)\big).$$

Turning to the θ_H type, his probability of reelection with rational voters is

$$\mathcal{R}_H^R = \nu_0\,\mu_0\big(s_R^*(\sigma_0)\big) + (1-\nu_0)\mu_{1\Delta}\big(s_R^*(\sigma_0)\big), \tag{15}$$

while with hindsight biased voters, it is

$$\mathcal{R}_H^B = \nu_0\, \mu_0\big(s_B^*(\sigma_0)\big) + (1-\nu_0)\mu_{1\Delta}\big(s_R^*(\sigma_1)\big). \tag{16}$$

The next proposition compares the politician's reelection prospects in the presence of rational and hindsight biased voters.

Proposition 2 *Suppose $\nu_0 < \nu_0^R$. Both low-ability and high-ability politicians are less likely to be reelected when facing hindsight biased voters than when facing rational voters: $\mathcal{R}_L^B < \mathcal{R}_L^R$ and $\mathcal{R}_H^B < \mathcal{R}_H^R$. Thus, hindsight bias increases political turnover.*

Our model predicts that political turnover – defined as the rate of replacement of the politician holding office – is larger when voters are hindsight biased (because both the low and the high type are less likely to be reelected). This result follows directly from the fact that, whatever the outcome, rational voters always have a (weakly) higher opinion of the politician than hindsight biased ones; see Lemma 4. The result is in line with conventional wisdom which holds that, when evaluating somebody else's performance, a person suffering from hindsight bias gives less credit than is due in case of success, and more blame than is warranted in case of failure.

Meanwhile, the overall effect of hindsight bias on second-period welfare is ambiguous and depends on parameters. We nevertheless point out that hindsight bias can be welfare-enhancing regardless of what happens in the second period: because voters discount the future, discipline is more important than selection for a sufficiently low discount factor.

6 Conclusion

We have constructed a political agency model where voters exhibit a cognitive deficiency known as hindsight bias: after the uncertainty about an event is resolved, they think that the realized outcome was more foreseeable than it actually was. In our model, voters have to evaluate the incumbent politician in order to decide whether to reelect him or replace him with a challenger. Politicians are assumed to differ in their ability, where ability is taken to mean the quality of the information they have about the welfare-maximizing policy. High-ability politicians are better informed than low-ability politicians and voters. In this setup, low-ability politicians have incentives to disregard public information on what the optimal policy is in order to appear to have superior private information. We have shown that, in this context, hindsight bias on the part of voters can act as a discipline device. This is because hindsight biased voters are less easily impressed by a successful reform – they think it was the obvious choice to make from the outset, even if the available information had actually

suggested otherwise. Therefore, they give an incumbent who succeeds with a reform policy in spite of public pessimism less credit than rational voters who perfectly recall their prior. Anticipating this, low-ability politicians are less likely to deviate from the welfare-maximizing policy.

The disciplining effect of hindsight bias is unambiguously beneficial for voters' first-period welfare. However, an overall welfare assessment also has to take into account the second (i.e., post-election) period. We have analyzed how hindsight bias affects the selection of the second-period official and shown that, under some conditions, both the low- and the high-ability politician are less likely to be reelected when voters are hindsight biased than when they are rational. This suggests that it may very well be the case that hindsight bias does not serve voters well in terms of second-period welfare. These qualifications notwithstanding, hindsight bias can be welfare-enhancing no matter what if voters discount future payoffs at a sufficiently high rate.

Our framework may be applicable to problems other than the political economy issues we have studied here. For example, our analysis may be relevant for promotion decisions in organizations (which, much like democratic elections, do not follow rules set forth in an explicit *ex ante* contract). Consider a human resource department that has to decide whether to promote an employee from inside the firm, whose actions and performance have been observed, or to hire an outsider for the job. In a firm, there typically will be some amount of public information concerning the way an employee is supposed to handle his task (in terms of the model, what the right choice of action is), but employees may also have superior information on their specific assignment. Our model would predict that, if anticipated, hindsight bias on the part of the human resource manager may prevent low-ability employees from deviating to suboptimal actions in order to appear smart, but not necessarily help in choosing the right candidate.

We close by noting that, with the benefit of hindsight, all of our results are, of course, obvious.

Appendix

A Proofs

Proof of Lemma 1:

The proof proceeds as follows. First, taking as given that the high-ability politician plays mechanically as stated in the lemma, we show that, as ν_0 tends to 1, we are always in a pure-strategy equilibrium, while as ν_0 tends to its lower bound, $1 - c/\Delta$, we are in a mixed-strategy equilibrium if $\lambda_I < \frac{c\Delta}{(\Delta-c)^2+c\Delta}$, which is true by assumption. Second, we show that the high-ability politician indeed finds it optimal to follow the equilibrium strategy.

A necessary and sufficient condition for a pure-strategy equilibrium where $s(\sigma_0) = 1$ is that type θ_L prefers a_0 even though voters believe that he will always follow the signal. Evaluating U_0^0 and U_1^0 at $s(\sigma_0) = 1$, and letting $\nu_0 \to 1$, we have $\lim_{\nu_0 \to 1} U_0^0 = (1-\phi)\lambda_I$, while $\lim_{\nu_0 \to 1} U_1^0 \to -\phi c$. Therefore, the low-ability politician strictly prefers a_0 to a_1 as ν_0 approaches 1, even if he could fool voters about his type by implementing a successful reform.

Meanwhile, as $\nu_0 \to 1 - c/\Delta$, the condition for a pure-strategy equilibrium is no longer satisfied since

$$\begin{aligned}\lim_{\nu_0 \to 1-c/\Delta} (1-\phi)\frac{\lambda_I}{\lambda_I + (1-\lambda_I)/\nu_0} &= \frac{(1-\phi)\lambda_I}{\lambda_I + (1-\lambda_I)\Delta/(\Delta - c)} \\ &< \lim_{\nu_0 \to 1-c/\Delta} \phi\big[(1-\nu_0)\Delta - c\big] + (1-\phi)(1-\nu_0) = (1-\phi)c/\Delta,\end{aligned}$$

where the inequality is due to the assumption that $\lambda_I < \frac{c\Delta}{(\Delta-c)^2+c\Delta}$.

Since the expressions of U_0^0 and U_1^0 are monotonic in ν_0, it follows that there must be a threshold ν_0^R as stated in the lemma. For values below ν_0^R, there is no pure-strategy equilibrium. The only possible equilibrium therefore is in mixed-strategies. For the type θ_L politician to be willing to randomize, voters' beliefs must be such that $U_0^0 = U_1^0$. Moreover, these beliefs must be derived from equilibrium strategies. Thus, the only $s(\sigma_0)$ that constitutes an equilibrium is obtained by equating (1) and (2), yielding (4).

We now show that, given the voters' beliefs, it is indeed optimal for the high-ability politician to choose the policy corresponding to ω. Consider first type $(\theta_H, \omega = 0)$. He prefers a_0 because

$$(1-\phi)\frac{\lambda_I}{\lambda_I + (1-\lambda_I)s_R^*(\sigma_0)/\nu_0} > -\phi c$$

for any $s_R^*(\sigma_0)$.

Now consider type $(\theta_H, \omega = 1)$. If $\nu_0 \geq \nu_0^R$, and hence $s_R^*(\sigma_0) = 1$, he prefers a_1 because

$$(1-\phi)\frac{\lambda_I}{\lambda_I + (1-\lambda_I)/\nu_0} < \phi(\Delta - c) + 1 - \phi.$$

Turning to the mixed-strategy case where $\nu_0 < \nu_0^R$ and hence $s_R^*(\sigma_0) < 1$, type $(\theta_H, \omega = 1)$ also strictly prefers a_1. Indeed,

$$(1-\phi)\frac{\lambda_I}{\lambda_I + (1-\lambda_I)s_R^*(\sigma_0)/\nu_0} < \phi(\Delta - c) + (1-\phi)\frac{\lambda_I}{\lambda_I + (1-\lambda_I)\big(1 - s_R^*(\sigma_0)\big)},$$

because (4) must hold.

Finally, we prove the claimed monotonicity property of the equilibrium strategy by applying the implicit function theorem. Let $F_0 \equiv U_0^0 - U_1^0$. We have

$$\frac{\partial s_R^*(\sigma_0)}{\partial \nu_0} = -\frac{\partial F_0/\partial \nu_0}{\partial F_0/\partial s}.$$

It is straightforward to see that $\partial F_0/\partial s < 0$, while $\partial F_0/\partial \nu_0 > 0$. Hence, $\partial s_R^*(\sigma_0)/\partial \nu_0 > 0$. ■

Proof of Lemma 2:

The proof is similar to the one for Lemma 1. First, taking the high-ability politician's play as given, we show that, as ν_1 tends to 1, we are in a pure-strategy equilibrium if $\lambda_I > 1 - \frac{\phi(\Delta - c)}{1-\phi}$, which is true by assumption, while as ν_1 tends to its lower bound, c/Δ, we are always in a mixed-strategy equilibrium. Second, we show that the high-ability politician indeed finds it optimal to follow the equilibrium strategy.

A necessary and sufficient condition for a pure-strategy equilibrium where $s(\sigma_1) = 0$ is that type θ_L prefers a_1 even though voters believe that he will always follow the signal. Evaluating U_0^1 and U_1^1 at $s(\sigma_1) = 0$, and letting $\nu_1 \to 1$, we have $\lim_{\nu_1 \to 1} U_1^1 = \phi(\Delta - c) + (1-\phi)\lambda_I$, while $U_0^1 = 1 - \phi$ whatever ν_1. By the assumption that $\lambda_I > 1 - \frac{\phi(\Delta - c)}{1-\phi}$, the low-ability politician therefore strictly prefers a_1 to a_0 as ν_1 approaches 1, even if he could fool voters about his type by playing a_0. As $\nu_1 \to c/\Delta$, we have $\lim_{\nu_1 \to c/\Delta} U_1^1 < \lim_{\nu_1 \to c/\Delta} U_0^1$ by

$$\lim_{\nu_1 \to c/\Delta} \phi(\nu_1 \Delta - c) + (1-\phi)\nu_1 \lambda_I = (1-\phi)\lambda_I c/\Delta < 1 - \phi.$$

Thus, the condition for a pure-strategy equilibrium is no longer satisfied.

Since the expressions of U_0^1 and U_1^1 are monotonic in ν_1, it follows that there must be a threshold ν_1^R as stated in the lemma. For values below ν_1^R, there is no pure-strategy equilibrium. The only possible equilibrium therefore is in mixed-strategies. For the type θ_L politician to be willing to randomize, voters' beliefs must be such that $U_0^1 = U_1^1$. Moreover, these beliefs must be derived from equilibrium strategies. Thus, the only $s(\sigma_1)$ that constitutes an equilibrium is obtained by equating (5) and (6), yielding (7).

We now show that, given the voters' beliefs, it is indeed optimal for the high-ability politician to choose the policy corresponding to ω. Consider first type $(\theta_H, \omega = 0)$. He prefers a_0 because

$$(1-\phi)\frac{\lambda_I}{\lambda_I + (1-\lambda_I)s_R^*(\sigma_1)/\nu_0} > -\phi c,$$

for any $s_R^*(\sigma_1)$.

Now consider type $(\theta_H, \omega = 1)$. If $\nu_1 \geq \nu_1^R$, and hence $s_R^*(\sigma_1) = 0$, he prefers a_1 because

$$1 - \phi < \phi(\Delta - c) + (1 - \phi)\lambda_I$$

is a necessary condition for the low type to play a pure strategy. In the mixed-strategy case where $\nu_1 < \nu_1^R$ and hence $s_R^*(\sigma_1) > 0$, type $(\theta_H, \omega = 1)$ also strictly prefers a_1 since

$$(1-\phi)\frac{\lambda_I}{\lambda_I + (1-\lambda_I)s_R^*(\sigma_1)/(1-\nu_1)} < \phi(\Delta - c) + (1-\phi)\frac{\lambda_I}{\lambda_I + (1-\lambda_I)\big(1 - s_R^*(\sigma_1)\big)}$$

follows from (7).

Finally, we prove the claimed monotonicity property of the equilibrium strategy by applying the implicit function theorem. Let $F_1 \equiv U_0^1 - U_1^1$. We have

$$\frac{\partial s_R^*(\sigma_1)}{\partial \nu_1} = -\frac{\partial F_1/\partial \nu_1}{\partial F_1/\partial s}.$$

It is straightforward to see that $\partial F_1/\partial s < 0$ and $\partial F_1/\partial \nu_1 < 0$. Hence, $\partial s^*(\sigma_1)/\partial \nu_1 < 0$. ■

Proof of Lemma 3:

First, taking as given that the high-ability politician plays mechanically as stated in the lemma, we show that, as ν_0 tends to 1, we are always in a pure-strategy equilibrium, while as ν_0 tends to its lower bound, $1 - c/\Delta$, we are in a mixed-strategy equilibrium if $\lambda_I < \frac{(\Delta-c)\Delta s_R^*(\sigma_1)+2c\Delta-\Delta^2}{(\Delta-c)\Delta s_R^*(\sigma_1)+c^2}$, which is true by assumption. We show that a high-ability politician indeed finds it optimal to play the claimed equilibrium strategy and finally the monotonicity property of the equilibrium strategy is established.

A necessary and sufficient condition for a pure-strategy equilibrium where $s(\sigma_0) = 1$ is that type θ_L prefers a_0 even though voters believe that he will always follow the signal. Evaluating U_0^0 and U_1^0 at $s(\sigma_0) = 1$, and letting $\nu_0 \to 1$, yields $\lim_{\nu_0 \to 1} U_0^0 = (1-\phi)\lambda_I$ and $\lim_{\nu_0 \to 1} U_1^0 = -\phi c$. As in the rational case, the low-ability politician strictly prefers a_0 to a_1 as the signal precision ν_0 approaches 1. But when ν_0 approaches its lower bound, $\nu_0 \to 1 - c/\Delta$, then the pure-strategy equilibrium condition is violated because, again evaluated at $s(\sigma_0) = 1$,

$$\begin{aligned}\lim_{\nu_0 \to 1-c/\Delta} U_0^0 &= \frac{(1-\phi)\lambda_I}{\lambda_I + (1-\lambda_I)\Delta/(\Delta - c)} \\ &< \lim_{\nu_0 \to 1-c/\Delta} U_1^0 = \frac{c}{\Delta}\left[\frac{(1-\phi)\lambda_I}{\lambda_I + (1-\lambda_I)(1 - s_R^*(\sigma_1))}\right],\end{aligned}$$

with the inequality due to $\lambda_I < \frac{(\Delta-c)\Delta s_R^*(\sigma_1)+2c\Delta-\Delta^2}{(\Delta-c)\Delta s_R^*(\sigma_1)+c^2}$.

Since both U_0^0 and U_1^0 are monotonic in ν_0, it follows that there must exist a threshold ν_0^B as stated in the lemma. For values $\nu_0 < \nu_0^B$, conditions for the pure-strategy equilibrium

candidate does not hold and therefore the only possible equilibrium is in mixed-strategies. For the θ_L type politician to be willing to randomize, voters' beliefs must be such that $U_0^0 = U_1^0$, with beliefs derived from equilibrium strategies. Thus, the only $s(\sigma_0)$ that constitutes an equilibrium is obtained by equating (8) and (9), yielding equation (11) stated in the lemma.

What remains to be shown is that a high ability politician chooses to play the policy corresponding to ω, given the biased voters' beliefs. Consider first type $(\theta_H, \omega = 0)$. This type prefers a_0 because for any $s_B^*(\sigma_0)$, $U(\sigma_0, a_0) > U(\sigma_0, a_1)$ which is,

$$(1-\phi)\frac{\lambda_I}{\lambda_I + (1-\lambda_I)s_B^*(\sigma_0)/\nu_0} > -\phi c.$$

For type $(\theta_H, \omega = 1)$ we need to consider two subcases. In the first case, if $\nu_0 \geq \nu_0^B$, in which a θ_L type plays the pure-strategy $s_B^*(\sigma_0) = 1$, the high-ability politician prefers action a_1 iff $U(\sigma_0, a_0) \leq U(\sigma_0, a_1)$ or,

$$(1-\phi)\frac{\lambda_I}{\lambda_I + (1-\lambda_I)/\nu_0} \leq \phi(\Delta - c) + (1-\phi)\frac{\lambda_I}{\lambda_I + (1-\lambda_I)(1 - s_R^*(\sigma_1))}. \tag{17}$$

In the second case, if $\nu_0 < \nu_0^B$, in which a θ_L type plays the mixed-strategy $s_B^*(\sigma_0) < 1$, type $(\theta_H, \omega = 1)$ also prefers a_1, iff $U(\sigma_0, a_0) \leq U(\sigma_0, a_1)$ or equivalently,

$$(1-\phi)\frac{\lambda_I}{\lambda_I + (1-\lambda_I)s_B^*(\sigma_0)/\nu_0} \leq \phi(\Delta - c) + (1-\phi)\frac{\lambda_I}{\lambda_I + (1-\lambda_I)\big(1 - s_R^*(\sigma_1)\big)}. \tag{18}$$

It is however sufficient to check whether (18) is satisfied because (18) implies (17) (for any ν_0). Note that a low type randomizes according to $s_B^*(\sigma_0)$ determined by the indifference condition given in (11). Since (11) holds with equality, it follows immediately that θ_H type's conditions (18) and hence (17) are both satisfied.

The proof concludes by establishing the claimed monotonicity property of the equilibrium strategy. For this we apply the implicit function theorem. Let $F_0 \equiv U_0^0 - U_1^0$, then we have

$$\frac{\partial s_B^*(\sigma_0)}{\partial \nu_0} = -\frac{\partial F_0/\partial \nu_0}{\partial F_0/\partial s}.$$

It is straightforward to see that $\partial F_0/\partial s < 0$, while $\partial F_0/\partial \nu_0 > 0$. Therefore $\partial s_B^*(\sigma_0)/\partial \nu_0 > 0$.■

Proof of Proposition 1:

We prove the proposition for the case where the σ_1 subgame has a pure-strategy equilibrium and then move on to the mixed-strategy case. A preliminary result used below is $\nu_0^R > \nu_0^B$, i.e. the threshold value of the signal precision in the σ_0 subgame is greater in the rational than in the biased evaluation regime. The result follows from comparing the RHS of equation (3) and (10) (cf. Lemma 1 and 3).

For a pure-strategy equilibrium in the σ_1 subgame, $s_R^*(\sigma_1) = 0$, we need $\lambda_I > 1 - \frac{\phi(\Delta - c)}{1-\phi}$ and $\nu_1 \geq \nu_1^R$ (cf. Lemma 2). Since $\nu_0^R > \nu_0^B$, it follows that $\forall\ \nu_0 \in (\nu_0^B, \nu_0^R)$, we have $s_B^*(\sigma_0) = 1$ by Lemma 1 while $s_R^*(\sigma_0) < 1$ by Lemma 3, and hence the claimed result holds. What remains to be shown in this case is that the claimed result is also true for $\nu_0 \leq \nu_0^B$. Comparing equation (4) and (11) , which determines the rational $s_R^*(\sigma_0)$ and respectively the biased $s_B^*(\sigma_0)$ (see Lemma 1 and 3), one notices that they differ only in the RHS term representing the politician's reputation when implementing a successful reform. Furthermore, since $\nu_1 \geq \nu_1^R$ by assumption, $s_R^*(\sigma_1) = 0$ by Lemma 2. Therefore, the last term on the RHS of (11) simplifies to $(1 - \nu_0)\lambda_I$. The payoff U_0^0 from playing a_0 in the rational and the biased case is the same and decreases with $s(\sigma_0)$, consult the LHS of (4) and respectively (11). The payoff U_1^0 from playing a_1 increases with $s(\sigma_0)$ in the rational case, but U_1^0 for rational and hindsight biased case coincide only at $s(\sigma_0) = s(\sigma_1) = 0$, as can be seen from RHS of (4) and respectively (11). Furthermore, $\forall\ s(\sigma_0) \neq 0$, expected utility U_1^0 is strictly greater with rational voters than with hindsight biased voters. Therefore, the intersection of U_0^0 and U_1^0 lies further to the left in the rational case than in the case of hindsight bias, which is what we needed to show.

We now turn to the case where the σ_1 subgame has a mixed-strategy equilibrium, $0 < s^*(\sigma_1) < 1$, which requires $\nu_1 < \nu_1^R$. The proof is similar to the pure-strategy case. Now, however, the payoff from deviating, U_1^0, coincides in the rational and biased case not at 0 but at $s(\sigma_0) = s_R^*(\sigma_1) > 0$. For any $s(\sigma_0) > s_R^*(\sigma_1)$, U_1^0 is larger with rational voters than with hindsight biased voters. Thus, for the claimed result to hold we need the intersection of U_0^0 and U_1^0 in the rational case – i.e., $s_R^*(\sigma_0)$ – to be situated to the right of $s_R^*(\sigma_1)$.[43] But this is exactly subject of Corollary 1. ■

Proof of Lemma 4:

Inequalities (12) and (13) follow directly from the fact that $s_R^*(\sigma_0) < s_B^*(\sigma_0)$ whenever $\nu_0 < \nu_0^R$, a result established in Proposition 1. Meanwhile, (14) holds because $s_R^*(\sigma_0) > s_R^*(\sigma_1)$; see Corollary 1. ■

Proof of Proposition 2:

By applying Lemma 4, we immediately get the required result: since $\mu_0\big(s_R^*(\sigma_0)\big) > \mu_0\big(s_B^*(\sigma_0)\big)$ and $\mu_{1\Delta}\big(s_R^*(\sigma_0)\big) > \mu_{1\Delta}\big(s_R^*(\sigma_1)\big)$ it must be the case that $\mathcal{R}_\theta^B < \mathcal{R}_\theta^R$ for all θ; the probability weights attached to the different posteriors do not matter. ■

[43] Note here and above: $s_R^*(\sigma_1) = s_B^*(\sigma_1)$ as explained in section 4.

B Elimination of alternative equilibria with criterion D1

It is a well-known fact that, because it does not pin down out-of-equilibrium beliefs, the PBE concept is often plagued by multiple equilibria. In our case, there effectively exist alternative equilibria; namely, pooling equilibria where all types of politician choose the same policy irrespective of their information. Consider the following sets of strategies and beliefs:

- All types pool on a_0, and voters believe that any politician who plays a_1 is of type θ_L with probability one, i.e. $\mu(\sigma, a_1, y) = 0$;
- all types pool on a_1, and voters believe that any politician who plays a_0 is of type θ_L with probability one, i.e. $\mu(\sigma, a_0, 0) = 0$.

The first of these candidates requires $\frac{1-\phi}{\phi}\lambda_I > \Delta - c$, the second $\frac{1-\phi}{\phi}\lambda_I > c$, to be an equilibrium.

Both of these equilibria can be eliminated using a refinement known as the D1 criterion which puts restrictions on out-of-equilibrium beliefs.[44] We show this for the first of the two candidates (pooling on a_0); the argument can be applied in an analogous way to the other.

Whatever his type, the politician's equilibrium payoff is $(1-\phi)\lambda_I$. Let γ denote a mixed action for the voters, i.e. γ is the probability of voting for the incumbent in the election at the end of period 1. Define $D\big((\theta, \Psi_\theta), a_1\big)$ as the set of mixed best responses to action a_1 that makes a politician of type θ and with information Ψ_θ strictly better off playing a_1 than with his equilibrium strategy,

$$D\big((\theta, \Psi_\theta), a_1\big) = \bigcup_{\mu} \{\gamma \in MBR(\mu, a_1) \ : \ (1-\phi)\lambda_I < \phi E(W|\Psi_\theta) + (1-\phi)\gamma\},$$

where $MBR(\mu, a_1)$ is the set of mixed best responses to action a_1 for posterior beliefs μ. Similarly, let $D^0\big((\theta, \Psi_\theta), a_1\big)$ denote the set of responses for which the politician is indifferent. According to the D1 criterion, a type (θ, Ψ_θ) can be deleted for action a_1 if there exists another type $(\theta, \Psi_\theta)'$ (i.e. of different ability or with different information), such that

$$D\big((\theta, \Psi_\theta), a_1\big) \cup D^0\big((\theta, \Psi_\theta), a_1\big) \subset D\big((\theta, \Psi_\theta)', a_1\big),$$

where $\subset$ denotes a strict inclusion.

Let us derive the sets $D\big((\theta, \Psi_\theta), a_1\big)$ for the different types in the most interesting case where $\sigma = \sigma_1$. We have

$$E(W|\Psi_\theta) = \begin{cases} \nu_1\Delta - c & \text{for } \theta_L \\ -c & \text{for } (\theta_H, \omega = 0) \\ \Delta - c & \text{for } (\theta_H, \omega = 1) \end{cases}$$

[44] D1, developed by Cho and Kreps (1987), is a slightly stronger version of Banks and Sobel's (1987) "divinity" concept.

The voters' best response to a_1 depends on μ. Suppose that the perceived ability of the challenger is λ_C. The voters' best response is "vote for incumbent" if $\mu > \lambda_C$, "vote for challenger" if $\mu < \lambda_C$, and any mixed action $\gamma \in [0,1]$ if $\mu = \lambda_C$. Thus, any γ is a mixed best response for some belief μ, and

$$\begin{aligned} D\big(\theta_L, a_1\big) &= (\lambda - \tfrac{\phi}{1-\phi}(\nu_1\Delta - c), 1] \\ D\big((\theta_H, \omega = 0), a_1\big) &= (\lambda + \tfrac{\phi}{1-\phi}\, c, 1] \\ D\big((\theta_H, \omega = 1), a_1\big) &= (\lambda - \tfrac{\phi}{1-\phi}(\Delta - c), 1]. \end{aligned}$$

Clearly, if $\nu_1 < 1$, $D\big(\theta_L, a_1\big) \cup D^0\big(\theta_L, a_1\big) \subset D\big((\theta_H, \omega = 1), a_1\big)$, so that type θ_L (and, *a fortiori*, type $(\theta_H, \omega = 0)$) can be pruned based on criterion D1. That is, voters should believe that a deviation to a_1 is infinitely more likely to come from type $(\theta_H, \omega = 1)$ than from θ_L, in which case they should reelect the incumbent. Anticipating this, the high-ability politician will not stick to his prescribed equilibrium strategy when observing $\omega = 1$, and the equilibrium breaks down.

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