INSTITUTE
OF ECONOMIC STUDIES
Faculty of Social Sciences
Charles University

BOARD BIAS, INFORMATION, AND INVESTMENT EFFICIENCY

Martin Gregor
Beatrice Michaeli

IES Working Paper 11/2024

Institute of Economic Studies,
Faculty of Social Sciences,
Charles University in Prague

[UK FSV – IES]

Opletalova 26
CZ-110 00, Prague
E-mail : ies@fsv.cuni.cz
http://ies.fsv.cuni.cz

Institut ekonomických studií
Fakulta sociálních věd
Univerzita Karlova v Praze

Opletalova 26
110 00 Praha 1

E-mail : ies@fsv.cuni.cz
http://ies.fsv.cuni.cz

Bibliographic information:
Gregor M., Michaeli B. (2024): " Board Bias, Information, and Investment Efficiency" IES Working Papers 11/2024. IES FSV. Charles University.

This paper can be downloaded at: http://ies.fsv.cuni.cz

Board Bias, Information, and Investment Efficiency

Martin Gregor[1]
Beatrice Michaeli[2]

[1]Institute of Economic Studies, Faculty of Social Sciences, Charles University
martin.gregor@fsv.cuni.cz
[2] UCLA Anderson School of Management
beatrice.michaeli@anderson.ucla.edu

March 2024

Abstract:
We study how interest alignment between CEOs and corporate boards influences investment efficiency and identify a novel force behind the benefit of misaligned preferences. Our model entails a CEO who encounters a project, gathers investment-relevant information, and decides whether or not to present the project implementation for approval by a sequentially rational board of directors. The CEO may be able to strategically choose the properties of the collected information---this happens, for instance, if the project is ``novel" in the sense that it explores new technology, business concept, or market and directors are less knowledgeable about it. We find that only sufficiently conservative and expansion-cautious directors can discipline the CEO's empire-building tendency and opportunistic information collection. Such directors, however, underinvest in projects that are not novel. From the shareholders' perspective, the board that maximizes firm value is either conservative or neutral (has interests aligned with those of the shareholders) and always overinvests in innovations. Boards with greater expertise are more likely to be conservative, but their bias is less severe. Our analysis shows that board's commitment power and bias are substitutes.

JEL: D83, D86, G30, G31, G34
Keywords: Empire-building, biased board, underinvestment, overinvestment, endogenous information

Acknowledgement: For comments and suggestions, we thank Aleksander Aleszczyk, Anil Arya, Tim Baldenius, Snehal Banerjee, Jeremy Bertomeu, Anne Beyer, Jonathan Bonham, Judson Caskey, Jonathan Craske, George Drymiotes, Ron Dye, Yonca Ertimur, Elia Ferracuti, Fabrizio Ferri, Paul Fischer, Henry Friedman, Jonathan Glover, Robert Goex, Wayne Guay, Ilan Guttman, Mirko Heinle, Zeqiong Huang, John Hughes, Xu Jiang, Navin Kartik, Rick Lambert, Volker Laux, Christian Leuz, Mark Maffett, Ivan Marinovic, Xiaojing Meng, Brian Mittendorf, Anya Nakhmurina, Stefan Reichelstein, Sander Renes, Katherine Schipper, Anastasiya Shamshur, Kevin Smith, Philip Stocken, Seung Yeon Yoo, Ronghuo Zheng, and participants at MIT, Wharton, Stanford, University of Chicago, Kellogg, Duke, LBS, Yale, Dartmouth, NYU, USC, UCLA, UT Austin, Rice, UIC, OSU, UCSD, Purdue, CUNY, Bristol, Miami Accounting Conference, 9th Annual Economics Theory Conference, ARW, EAA, EFMA, and the Czech Economics Society. Martin Gregor acknowledges financial support from the Czech Science Foundation (GA CR 20-03517S) and the Cooperatio Program at Charles University.

1 Introduction

It is not uncommon for CEOs to harbor aspirations of creating "corporate empires" (Hope and Thomas 2008; Décaire and Sosyura 2021). Despite being outweighed by leadership skills, strategy, and vision—the reasons these CEOs were hired in the first place—such aspirations can still pose challenges for shareholders. Incentive contracting may not fully curb empire-building ambitions, or the costs of doing so may be prohibitively high (Shleifer and Vishny 1989; Gregor and Michaeli 2023). Consequently, to safeguard the shareholders' interests, companies entrust their corporate boards with the approval of significant investment opportunities, such as cash acquisitions of other firms or major product launches (Useem 2006). Grasping the intricate tradeoffs in approval decisions necessitates an understanding that directors may have private benefits, costs, or innate biases influencing their investment preferences. A stream of prior literature (e.g., Adams and Ferreira 2007; Baldenius, Melumad, and Meng 2014) indicates that aligning the preferences of boards and CEOs enhances the communication of exogenously given information. In practice, investment-relevant information (such as data about an acquisition target, customer demand, or technological feasibility) often needs to be actively collected, with CEOs potentially guiding this process (for instance, by selecting the due diligence team or focus group). This paper examines how CEOs' ability to influence information gathering affects the optimal alignment of interests within the leadership team and the efficiency of corporate investments.

We build a model in which a CEO ("she") finds an investment project and decides whether or not to present it for approval to a board of directors. The preferences of the shareholders, the CEO, and the board are such that each favors investments with a value exceeding a player-specific threshold. These thresholds not only determine the alignment of interests among the players but also parsimoniously reflect pecuniary and non-pecuniary benefits, costs, as well as inherent characteristics and attitudes toward corporate investment and expansion. In line with classic agency theory (Jensen 1986; Shleifer and Vishny 1989; Stulz 1990; Jensen and Murphy 1990), we posit that the CEO is an empire-builder whose threshold is below that of the shareholders. The board's threshold can assume any value: In comparison to the shareholders, the board can be classified as "expansionist" (when most directors favor company expansion due to entrepreneurial background, perks or social connections with the CEOs so their threshold is relatively low), "conservative" (when most directors are cautious about company expansion as a result of desire to maintain status quo and financial prudence, prioritize stability over growth, or focus on current operations so their threshold is high), or "neutral" (a balanced mix of expansionists and conservatives so the board overall is aligned with the shareholders). Throughout the paper, we refer to the player-specific thresholds as "types" or "biases."

When bringing the project for approval to the board, the CEO gathers investment-relevant information. The nature of the project may render the CEO unable to control the properties of the information that she collects, especially when the project is similar to previous operations or the directors are knowledgeable about the industry. We dub such a project "routine," and assume its value is (without loss of generality) fully revealed from the collected information. Conversely, when the project involves new technology, a business concept, or a market, the CEO has more flexibility and thus can select the properties of the information. Such a project is referred to as "novel," and the CEO's decision-making process is modeled as a Bayesian persuasion problem. In our model, this simplifies to an ex-ante choice of a reporting cutoff, whereby projects with a value above (below) the cutoff are reported as high (low). Selecting a greater cutoff increases the expected value of the project, conditional on either report. The CEO can "veto" a project in the sense that she can choose not to present it for approval.

We commence our analysis with a benchmark case in which the board commits to approving projects that meet a predetermined hurdle rate. For routine projects, where the value is perfectly revealed, we find that the board aligns the hurdle precisely with its threshold (type). For novel projects, the CEO can strategically report various projects as having high value; the critical consideration here is that the project's expected value, given a high report, must be sufficiently high to meet the pre-committed hurdle rate. Evidently, if the board is less expansionist than the CEO and sets the hurdle for novel projects at its threshold (type), an empire-building CEO pools some low-value projects with high-value projects, securing approval for all. To counter this, the board optimally chooses a higher hurdle for novel projects. In the aftermath, because of the CEO's veto power, only projects—whether routine or novel—that meet or surpass the higher of the CEO's and the board's types/biases are undertaken. Consequently, efficient investments in the benchmark case with commitment arise when the board's preferences are perfectly aligned with those of the shareholders; that is, the optimal board with commitment power is neutral.

We proceed with the analysis of our main model, where corporate boards cannot commit to investment approval policies. Suppose the CEO encountered a novel project. If the board's preferences perfectly align with those of the CEO, meaning their types are the same, then the CEO can simply set the reporting cutoff at her threshold (type) and present only the novel projects reported as having high value, which the board will approve. This is true also when the preferences are only slightly misaligned or when the board has a strong pro-expansion bias. However, if the board is very conservative, such a strategy results in rejection. To avoid this outcome, the CEO optimally increases the reporting cutoff so that the expected value of novel projects reported as high is just enough for the board's approval. Faced with an opportunistically-set reporting cutoff, the board may under- or overinvest in novel projects from the shareholders' perspective. Notably, a board with significantly high conservative bias elicits a cutoff choice that results in efficient novel investments—this result comports with empirical evidence about the impact of activist pressure for nomination of cost-cutting directors (Brav, Jiang, Ma, and Tian 2018; Maffett, Nakhmurina, and Skinner 2022) and director independence requirements (Rim and Sul 2020). As we explain below, this beneficial disciplining effect of misaligned preferences on persuasion has not been studied in prior literature. One could draw a parallel to our benchmark setting: there, disciplining the CEO is achieved via a commitment to a high hurdle rate. In the main model, this effect is achieved via a conservative bias. This observation implies that boards' commitment power and bias are substitutes.

When the CEO encounters a routine project she has no ability to persuade the board via a strategically constructed report—approval is granted if the revealed project value exceeds the board's type. Thus, while a very conservative board invests efficiently in innovations, it can reject a routine project against the shareholders' interest. So which board type maximizes firm value? In our setting, a board with pro-expansion bias can never be optimal because it distorts decisions about both sorts of projects. A board that is only mildly conservative is also suboptimal—it not only distorts decisions about routine investments but also fails to discipline the CEO's opportunistic reporting about novel projects. We find that only one of two board types can be optimal—neutral or very conservative—but neither can fully undo the CEO's empire-building. In equilibrium, the board approves some (but not all) empire-building projects: firms *overinvest* in innovations but may or may not *underinvest* in routines.

Which of the two board types is optimal depends on the relative magnitude of the expected gain from improved approvals of novel projects and the expected loss from distorted approvals of routine ones. When the CEO is more likely to find a routine opportunity, the expected loss is relatively large and outweighs the expected gain—thus the optimal board is more likely neutral. However, when the CEO has a severe tendency to overinvest, a conservative board that disciplines the CEO is preferable from the shareholders' perspective. This finding aligns with recent anecdotal evidence—for example, a Korn Ferry briefing on mergers and acquisitions notes that "some directors may find themselves trying to temper, if not fight back against, their CEOs' urge to merge" and adds that it is "important... for acquiring company directors to exercise fiscal prudence and strategic oversight."[1] Overall, our results predict that in environments with heterogeneous projects the distribution of optimal boards is bimodal. Companies managed by mildly biased CEOs have neutral boards and those managed by extreme empire-builders have conservative boards.

We extend the analysis by allowing the board to acquire costly information about novel projects (information about routines is already perfect). After reviewing the CEO's report, the board chooses a cutoff such that a good (bad) message is generated if the value is above

[1] The briefing is available at https://www.kornferry.com/insights/briefings-for-the-boardroom/opposing-mergers–the-silent-

(below) the cutoff. From the board's perspective, the most useful message is when the cutoff coincides with its innate threshold/type. However, doing so is costly, and the incurred cost increases with the probability that the acquired information inspires the board to change the decision it would have taken solely based on the CEO's report. Therefore, the board acquires only imperfect information. What can the CEO do in response? We find that she is indifferent between adjusting the reporting cutoff to provide the same information that the board would optimally acquire, sticking to the reporting cutoff she would have chosen in the main model, or choosing any cutoff in between.[2] While these options prompt different degrees of board's learning at a varying cost, they all yield an identical ex-post outcome. Though the CEO's ability to get all her favored novel projects approved is restricted, our result that the optimal board is either neutral or very conservative remains valid. Our study reveals that when the cost of acquiring information is low (e.g., due to directors' experience or qualifications), the optimal board is more likely to be biased (complementarity between bias and expertise). However, we also find that the optimal level of bias decreases (substitution between bias and expertise). Consequently, we predict that conservative boards are more common in industries with professionals who have more experience and expertise. Nevertheless, the greater the directors' expertise, the less conservative the board will be.

Related literature. Our paper contributes to several strands of literature. We predict that an intermediary (board of directors) having preferences that *severely differ* from those of an agent (CEO) elicits precise information that benefits a principal (shareholders). This is a significant departure from the predictions in a stream of literature that makes the case for *aligned* preference in settings where the agent is exogenously endowed with perfect information and can misrepresent it at no cost (e.g., Dessein 2002; Mitusch and Strausz 2005; Adams and Ferreira 2007; Harris and Raviv 2008; Baldenius, Melumad, and Meng 2014; Chakraborty and Yilmaz 2017).[3] The findings differ because in our model the sender may be able to choose

[2]The second option is related to observations that boards "rely mainly on the chief executive and the company's management for information" (The Economist, 2001) and recent work on the effects of receivers' information acquisition on senders' persuasion (Caplin, Dean and Leahy 2019; Matyskova and Montes 2023).

[3]A few corporate governance studies consider models with verifiable disclosure (Malenko 2014) or costly

the properties of the collected information. We believe this assumption is descriptive in many contexts, especially when directors are less knowledgeable about new concepts or markets, so management has more flexibility in guiding the information collection process.

Like us, several studies also call for misalignment, but their predictions are driven by different forces than ours—we contribute by studying a novel force behind the benefit of diverged preferences. In Dewatripont and Tirole (1999) multitasking leads to competition for information acquisition among multiple agents and this is best utilized by the principal when the agents have different preferences. Che and Kartik (2009) study differences in prior beliefs (arising only under uncertainty), whereas we study differences in preferred policy (arising even under certainty). In their disclosure model, the greater the difference between the priors of the sender and the receiver, the more precise and costly information the sender acquires due to the expectation that it will change the receiver's beliefs. In our persuasion model, misalignment does not affect the cost-benefit ratio of information as its acquisition is cost-free for the sender (CEO). Importantly, Che and Kartik (2009) demonstrate that disagreement over priors in their disclosure game works differently than divergent preferences: if the sender and the receiver in their model were to have different preferences but a common prior, then the receiver would always prefer an unbiased sender which is different than our findings.

In Baldenius, Meng, and Qiu (2019), friendly directors receive more precise information from the CEO, whereas antagonistic ones search for information independently. Therefore, antagonistic boards can be optimal when the information from outsiders is more valuable. In our model, this channel is absent as the CEO has access to perfectly precise information (i.e., the board has no informational advantage) and chooses report properties that may prevent the board from learning (i.e., the board's information acquisition problem disappears in equilibrium). In Aghamola and Hashimoto (2020) a less friendly intermediary is more likely to fire the CEO. To avoid this outcome, the CEO boosts productivity by reducing the bias in

misreporting (Gregor 2020; Chen and Laux 2021) and do not study optimal interest alignment. Among other corporate governance aspects studied by the literature are: CEO turnover (Laux 2014; Meng 2020), performance manipulation (Drymiotes 2009), ability to monitor (Drimyotes 2007), board commitment to decision rule (Baldenius, Meng, and Qiu 2021), incentive compensation (Qiu 2020; Gregor and Michaeli 2023, Feng, Luo, and Michaeli 2022), and expertise (Chen, Guay, and Lambert 2020).

her report. In our model, this incentive is missing as we abstract from CEO turnover. In Ball and Gao (2023), the benefit from misalignment arises due to the interplay between the agent's bias and a restriction on the available policies. There, a biased agent must examine whether to select an extreme policy (as a fine-tuned one is unavailable), which encourages information acquisition. In our model, this channel is absent because the binary board's action (approve or reject the project) cannot be restricted. Misalignment can also be beneficial when the agent interacts with third parties such as suppliers, business partners and competitors: in oligopolies, delegating the product decisions to an agent who competes aggressively serves as a pre-commitment device (Fershtman and Judd 1987) and can shape the managers' disclosure choices (Bagnoli and Watts 2015). In static bargaining, appointing a less interested agent forces the bargaining partner to reduce her share of the surplus (Segendorff 1998).

Our paper also relates to the capital budgeting literature (e.g., Antle and Eppen 1985; Bernardo, Cai, and Luo 2001; Baldenius 2003; Dutta 2003; Baldenius, Dutta and Reichelstein 2007; Dutta and Fan 2009; Baiman, Heinle and Saouma 2013; Heinle, Ross and Saouma 2014; Bastian-Johnson, Pfeiffer and Schneider 2013; 2017) where a principal commits to an ex-ante hurdle for investing. Typically, this literature recommends that the hurdle is set sufficiently high, which results in ex-post underinvestment. Our analysis differs in several dimensions: First, our main model predicts overinvestment in innovations and potentially underinvestment in routines. Second, unlike capital budgeting literature, the CEO in our model does not have private information but rather strategically designs a system to generate public information. Third, in our main model, the board of directors has no commitment power, and its ex-post approval decision depends on the board's expansion bias. We compare this main setting with a benchmark case where the board has commitment power (similar to the capital budgeting literature) and show that commitment and conservative bias are substitutes. Notably, in our benchmark case, there is no ex-post investment distortion (in contrast to capital budgeting studies). This difference is due to the endogenous nature of information in our model.

Our observation that commitment and bias are substitutes is related to findings in Laux

(2008) where, if the board is sequentially rational and cannot commit to not renegotiating, the shareholders prefer a board that is friendly to the CEO over an independent one. The main driving force in Laux (2008) is that it is cheaper for a friendly board to motivate the CEO's effort and extract the CEO's private information at the contract renegotiation stage. In contrast, information in our model is symmetric at every point in time and, therefore, cannot be extracted via a contract. However, a conservative (i.e., unfriendly to the CEO) board can discipline the CEO's endogenous acquisition of public information.

Lastly, we contribute to the Bayesian persuasion literature.[4] Unlike the extant work, our paper focuses on the optimal alignment of interests between senders and receivers. In an extension, we consider the board's learning option, which relates to the literature incorporating the receiver's information acquisition.[5] The threat of the board's learning disciplines the CEO (similar to other models with monitoring threat, e.g., Townsend 1979). This result relates to the findings of Matysková and Montes (2023), Caplin, Dean, and Leahy (2019), and Huang (2016), but unlike these studies, our focus is on the optimal misalignment between the interests of the sender and the receiver as well as the effect of learning costs on this misalignment.

2 Model

We consider a risk-neutral CEO ("she") and a risk-neutral board of directors running a firm on behalf of a group of risk-neutral shareholders. The CEO finds a significant investment opportunity ("project") and decides whether to present it ($d = 1$) or not ($d = 0$) to the board for consideration. The board approves ($a = 1$) or rejects ($a = 0$) the implementation.

Players' preferences and biases. The ex-post utility of player $j \in \{S, C, B\}$ (share-

[4]The model (Kamenica and Gentzkow 2011) has been extended to multiple receivers (Michaeli 2017), multiple senders (Gentzkow and Kamenica 2017a), interaction with voluntary disclosure (Friedman, Hughes and Michaeli 2020, 2022), agency problems (Göx and Michaeli 2019), liquidation decisions (Bertomeu and Cheynel 2015), signaling (e.g., Jiang and Yang 2017; Dordzhieva, Laux and Zheng 2020), mutual persuasion (Jiang and Stocken 2019), and asset pricing (Cianciaruso, Marinovic and Smith 2020). Early work (e.g., Arya, Glover, and Sivaramakrishnan 1997; Göx and Wagenhofer 2009) considers ex-ante information design.

[5]This is also broadly related to dissemination decisions in the presence of external information (Ebert, Schäfer and Schneider 2019; Frankel, Guttman and Kremer 2020; Libgobber, Michaeli and Wiedman 2023).

holders, CEO, board) is

$$v_j(a, d, \theta) = a \cdot d \cdot (\theta - \theta_j), \tag{1}$$

where $\theta \in [\theta_{min}, \theta_{max}]$ is the project value with $-\infty \leq \theta_{min} < 0 < \theta_{max} \leq +\infty$. The player-specific type $\theta_j \in [\theta_{min}, \theta_{max}]$ is common knowledge and captures misalignment of interests in a parsimonious way: each player prefers that projects with $\theta \geq \theta_j$ are undertaken (presented *and* approved) rather than not.[6] This parameter reflects the players' pecuniary and non-pecuniary benefits, costs or inherent investment attitudes. We also refer to the player's type as "bias" and assume the following:

(i) Without loss of generality, θ_S is zero so that the shareholders naturally benefit from projects with positive value and lose from projects with negative value. To facilitate comparison across players, we continue to refer to it in the text as θ_S.

(ii) The CEO's type is lower than that of the shareholders, $\theta_C < \theta_S$. That is, the CEO is an empire-builder (Baumol 1959; Marris 1964; Williamson 1964; Jensen 1986; Shleifer and Vishny 1989; Stulz 1990; Jensen and Murphy 1990; Hart 1995) and prefers that not only value-enhancing projects but also those with $\theta \in [\theta_C, \theta_S]$ are presented and approved—occasionally, we refer to the latter as "empire-building projects."[7]

(iii) The board's type can assume any value so that, compared with the shareholders, the board can be "neutral" ($\theta_B = \theta_S$), "expansionist" ($\theta_B < \theta_S$), or "conservative" ($\theta_B > \theta_S$). Directors could have a pro-expansion bias if they are close with the CEO (e.g., same social circle), have an entrepreneurial background, or favor company expansion for other reasons (e.g., perks). They could have a conservative bias and be cautious about company expansion due to a desire to maintain the status quo, prioritize stability over growth, or focus on current operations and financial prudence (Kroszner and Strahan

[6]Predictions remain qualitatively similar if players observe the types of other players with noise.

[7]We discuss the outcome when $\theta_C > \theta_S$ in footnote 20 and make additional comments in the discussion of assumptions below.

2001; Bertrand and Mullainthan 2003; Baldenius, Meng, and Qiu 2019).[8] In addition to these reasons, the directors' bias could also result from pecuniary and non-pecuniary benefits and costs (Gregor and Michaeli 2023). The overall bias of the board depends on the bias of the majority of the members—neutral boards are a balanced mix.[9]

Project category and information structure. The project could involve a new technology, business concept or market. In such cases, the project is observably classified as "novel." Otherwise, it is labeled "routine." A fraction $p \in (0, 1)$ of the investment opportunities in the economy are routine and the rest are novel. To capture any potential differences between the two categories of projects, we assume that the value of a routine project is drawn from a differentiable cumulative distribution G (with a corresponding probability density function g) and that of a novel project—from a differentiable cumulative distribution F (with a corresponding probability density function f). Finding a project means drawing a project from the pool of investment opportunities characterized by the joint probability distribution function of project category and project value.

At the onset of the game none of the players observes the underlying value θ but, after finding a project and before involving the board, the CEO can initiate collection of information about it. For novel projects, the CEO *can control* the properties of the collected information due to lack of board's familiarity with the concept or the market.[10] In particular, the CEO

[8]Deloitte (2015) documents that boards are often "more worried about . . . brand protection rather than growth" and "financially conservative with regard to spending and budget." Bertrand and Mullainthan (2003) emphasize the desire to "avoid the difficult decisions . . . associated with . . . starting new plants." Baldenius, Meng, and Qiu (2019) explain that (antagonistic in their terminology) board bias "could reflect a 'quiet life' preference (Bertrand and Mullainathan 2003) . . . which can be interpreted as 'sticking to the status quo'" or could arise if the directors "represent debtholders (Kroszner and Strahan 2001), or are accountants or academics concerned about the risk of high-profile failures for reputational reasons . . . [and] prefer an investment scale smaller than that which maximizes the net present value (NPV)." Directors with certain backgrounds may be more careful regarding company growth. For instance, accountants could prioritize financial prudence and cost control over aggressive company expansion, while lawyers may be concerned about legal complexities, compliance issues, or regulatory challenges, making them more cautious about growth strategies.

[9]In our model, the board of directors is a collective entity making decisions that maximize the average preferences of its members (see also Li 2001; Harris and Raviv 2008; Baldenius, Meng and Qiu 2019). The various ways a collective decision can be made are beyond the scope of this study. Our results extend to a setting in which collective decisions are based on a majority rule—in such case, the preferences of the median member determine the decision.

[10]For simplicity, we assume that the CEO has full control over the properties of the collected information if

chooses a report structure, i.e., a distribution of report realizations and a distribution of the project value conditional on any given report realization. For instance, the CEO could select the due diligence team for an acquisition target, choose the focus group evaluating market demand, fix the experiment protocol for determining technological feasibility, or design the medical trial for drug effectiveness. This is essentially a persuasion problem and, within the confines of our model, the CEO is at least weakly better off selecting binary reports with realizations that are supported by disjoint intervals of project values (see Appendix A.2 for detailed explanation). The CEO's choice of report structure is then fully characterized by the choice of a reporting cutoff $\theta_R \in [\theta_{min}, \theta_{max}]$ such that a low report $r = l$ is generated if $\theta < \theta_R$ and a high report $r = h$ otherwise.[11]

To streamline the analysis, we define $H(\cdot)$ to be the inverse function of the h-conditional expected value $\mathbb{E}[\theta | r = h, \theta_R]$ and $L(\cdot)$ to be the inverse function of the l-conditional expected value $\mathbb{E}[\theta | r = l, \theta_R]$. Each of these functions yields a reporting cutoff θ_R that corresponds to a given conditional expected value. The report is verifiable and cannot be withheld if the project is presented (see discussion of this assumption below). As for routine projects, the CEO *lacks control* over the information, potentially because directors possess knowledge about such projects, which renders the CEO unable to steer the collection of information. In this case, a public signal $s = \theta$ is generated.[12] Based on the observed information, the CEO decides whether or not to present the project to the board. There are no payoff consequences for not presenting.

Timeline. Figure 1 presents the timeline of the events. At date 1, the CEO finds a project with observable type (novel or routine). At date 2, if the project is novel, the CEO chooses the reporting cutoff θ_R and an observable report $r \in \{l, h\}$ is generated. If the project is routine, an observable signal $s = \theta$ is generated. At date 3, the CEO decides whether or not

the project is novel. In footnote 17, we discuss the outcome when the board learns θ with some probability, either because it seizes control over the information collection in the company or because of some cost-free source of information.

[11] Having control over the properties of the information about novel projects means that the CEO can freely choose θ_R, i.e., it is not contractible (due to lack of directors' or company familiarity with innovations).

[12] Our results are qualitatively similar if s estimates θ with a sufficient precision or if $s = b$ when $\theta < \theta_B$ and $s = g$ otherwise. In the latter case, the ability of the CEO to veto certain routine projects is limited.

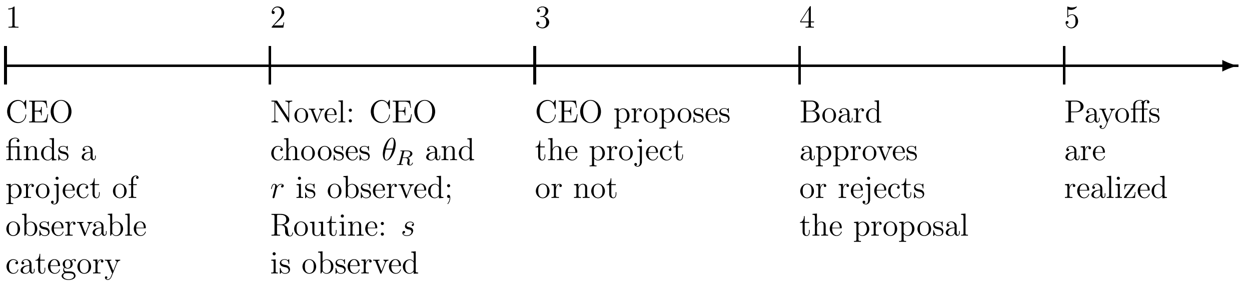


Figure 1: Timeline of events

to present the project to the board. At date 4, the board approves or rejects the project. At date 5, the payoffs are realized.

Discussion of assumptions. We now list several model assumptions and discuss whether they impact the robustness of our analysis:

1. *Information acquisition.* Our main model posits that only the CEO collects information. Section 5.1, Appendix A.5, and Appendix A.6 allow the board to acquire information (e.g., hire an advisor or exert a costly effort to learn). Our main results remain qualitatively similar.

2. *Project-category-independent bias.* We assume that the board bias does not depend on the project category (routine or novel)—this is consistent with the bias reflecting benefits, costs, or inherent attitudes toward company expansion that do not depend on the nature of the project. Section 5.2 relaxes this assumption.

3. *Finding the project.* We assume that the CEO considers the first investment opportunity she encounters. Appendix A.1 allows the CEO to draw from the pool of opportunities until she finds a project from the category (routine or novel) that she prefers. This does not change our results qualitatively.

4. *Verifiability.* The assumption that the report is verifiable fits our setting: A proposal for an investment project of significant importance has to be supported by convincing

evidence of the project feasibility—e.g., the results of due diligence process, market test, experiment, or drug trial—before involving the board (Useem 2006). Once collected, this evidence is available within the company, and the board can request it. Thus it is hard for the CEO to conceal or misrepresent it, which may also be associated with harsh legal consequences. For example, the former CEOs of Kmart and Kentucky aluminum company faced significant legal charges for providing misleading information to their boards (Peterson 2003; Associated Press 2020). To this end, the assumption that the report is verifiable arises naturally. However, *this assumption is not critical*:

(i) Allowing the CEO to withhold the report yields an identical outcome to that in the main analysis as the information contained in the report unravels (Gentzkow and Kamenica 2017b; Kamenica 2019).

(ii) Appendix A.3 allows the CEO to receive additional (private) information and send non-verifiable messages at no cost (cheap talk) after the optimally constructed public report is generated. This does not alter our results.

(iii) Appendix A.4 lets the CEO privately observe r and misrepresent it at a cost. Our main results continue to hold qualitatively.

5. *Contracting.* We focus on preference misalignment for given compensation. Concurrent research finds that it is often not optimal to eliminate agents' innate characteristics contractually even if strong monetary incentives are available. For example, Gregor and Michaeli (2023) find that: (i) it may not be optimal to fully eliminate a CEO's empire-building tendency via contracting; and (ii) it may be optimal to strengthen a board's conservative tendency via incentive contracting. As information in our setting is symmetric at every point of time, a screening contract can not be written. The possibility that information design may be contracted (or, more broadly, determined by the board) is captured in our model by the presence of routine projects.

3 Benchmark With Commitment to Approval Policy

We commence with a brief benchmark case where, at the game's onset (date 0), the board can commit to approving a presented project if its expected value meets or exceeds a specified project-category-dependent "hurdle" rate $\{\rho^{novel}, \rho^{routine}\}$.

Lemma 1. *Under the benchmark with commitment power:*

(i) If $\theta_B \leq \theta_C$, the board chooses hurdle rates $\rho^{routine} \in [\theta_{min}, \theta_C]$ and $\rho^{novel} \in [\theta_{min}, H^{-1}(\theta_C)]$.

(ii) If $\theta_B > \theta_C$, the board chooses hurdle rates $\rho^{routine} = \theta_B$ and $\rho^{novel} = H^{-1}(\theta_B) > \theta_B$.

The CEO sets reporting cutoff $\theta_R = \max\{\theta_C, \theta_B\}$. She presents novel projects with $r = h$ and routine ones with $s \geq \max\{\theta_C, \theta_B\}$. The firm undertakes all novel and routine projects with $\theta \geq \max\{\theta_C, \theta_B\}$.

First, consider a board that is more biased towards expansion than the CEO ($\theta_B \leq \theta_C$). While such board would like to undertake all routine projects with $\theta \geq \theta_B$, it cannot achieve this as the CEO only presents for approval those with $s = \theta \geq \theta_C$. Thus, the board, in this case, is indifferent between any $\rho^{routine} \leq \theta_C$; with either of these hurdle rates, only routine projects with $\theta \geq \theta_C$ are undertaken. For novel projects, the CEO achieves her most desired outcome by simply setting $\theta_R = \theta_C$ and presenting only projects with $r = h$. The expansionist board in this case is indifferent between any $\rho^{novel} \leq H^{-1}(\theta_C)$; all of these hurdle rates yield that only novel projects with $\theta \geq \theta_C$ are undertaken. To summarize, when the board is strongly biased toward expansion, the firm implements routine and novel projects with a value of at least θ_C.

Second, consider a board that is more conservative about expansion than the CEO ($\theta_B > \theta_C$). Now, there are no projects that are favored by the board but not by the CEO. The opposite, however, is not true. Thus, while the CEO's veto power is not a threat anymore, her opportunistic choice of reporting cutoff is. By committing to $\rho^{routine} = \theta_B$ and $\rho^{novel} = H^{-1}(\theta_B)$, the board can curb the CEO's empire-building and ensure that routine and novel projects with $\theta \geq \theta_B$ are presented and approved, i.e., the board achieves its most desired outcome. It is now straightforward to see that under the benchmark with commitment power, the shareholders are best off if the board is neutral, $\theta_B = \theta_S > \theta_C$. By Lemma 1 (ii), such board chooses $\left(\rho^{routine}, \rho^{novel}\right) = (\theta_S, H^{-1}(\theta_S))$ which ensures efficient investments, i.e., that all projects favored by the shareholders (those with value $\theta \geq \theta_S$) are undertaken.[13]

Lemma 2. *From a shareholders' perspective, the optimal board with commitment power is neutral with $\theta_B = \theta_S$ and invests efficiently in both routine and novel projects.*

Our benchmark case implies that the optimal board with commitment power chooses $\rho^{novel} > \rho^{routine}$. This result provides a novel explanation of why hurdle rates for innovations in practice are higher and exceed what a standard application of the NPV rule would have suggested. The board's commitment power to such hurdles fully mitigates the CEO's empire-building tendency and ensures efficient investments.

4 Benefit From Conservative Boards

We now return to the main model where the board cannot commit to hurdle rates and illustrate the benefit of nominating conservative boards in such settings.

Board's approval decision. A sequentially rational board (i.e., a board without commitment power) approves a presented routine project at date 4 if and only if the (revealed by the signal s) value θ is at least θ_B. If the presented project is novel, the board grants an approval if its interim (expected at date 4) payoff from an undertaken project, $\mathbb{E}[\theta|r, \theta_R] - \theta_B$, at least weakly exceeds the zero-payoff from rejection. To characterize the report-specific decision, a_r, we note that at the reporting cutoffs $L(\theta_B)$ and $H(\theta_B)$ the board is indifferent (between approving and rejecting) after low and high reports, respectively.[14]

[13]Note that the neutral board is uniquely optimal since both $\rho^{routine}(\theta_B)$ and $\rho^{novel}(\theta_B)$ are strictly increasing in θ_B and any other board would invest inefficiently.

[14]In Section 2, we defined $H(\cdot)$ and $L(\cdot)$ as the inverse functions of $\mathbb{E}[\theta|r = h, \theta_R]$ and $\mathbb{E}[\theta|r = l, \theta_R]$, respectively. In essense, $L(\theta_B)$ satisfies $\mathbb{E}[\theta|r = l, \theta_R = L(\theta_B)] - \theta_B = 0$ and $H(\theta_B)$ satisfies $\mathbb{E}[\theta|r = h, \theta_R = H(\theta_B)] - \theta_B = 0$. Because $\mathbb{E}[\theta|r = l, \theta_R] \leq \mathbb{E}[\theta]$ and $\mathbb{E}[\theta|r = h, \theta_R] \geq \mathbb{E}[\theta]$, the cutoff $L(\theta_B)$ is relevant when $\theta_B \leq \mathbb{E}[\theta]$ and $H(\theta_B)$—when $\theta_B \geq \mathbb{E}[\theta]$. We provide further details in the Appendix.

Lemma 3 (Board's approval of novel projects for given reporting cutoff)**.**

(i) When $\theta_B \leq \mathbb{E}[\theta]$, the board rejects the presented novel project if and only if the report is low and the reporting cutoff is below $L(\theta_B)$; that is, $a_h = 1$ and $a_l = \mathbb{1}_{\theta_R \geq L(\theta_B)}$.

(ii) When $\theta_B > \mathbb{E}[\theta]$, the board approves the novel project if and only if the report is high and the reporting cutoff is at least $H(\theta_B)$; that is, $a_l = 0$ and $a_h = \mathbb{1}_{\theta_R \geq H(\theta_B)}$.

Figure 2 illustrates Lemma 3 and distinguishes between four problem regions. A board with relatively low type, $\theta_B \leq \mathbb{E}[\theta]$, is easily convinced to ratify the project. When the reporting cutoff is large (region $\mathcal{P}_1$), the expected value of the novel project, conditional on either report realization, is high and exceeds the board's type—thus the board always approves. However, when the reporting cutoff is small (region $\mathcal{P}_2$), the expected value of the project, conditional on $r = l$, is too low for approval even by a board with low type—as a result, the board ratifies the novel project only if the report is high. Furthermore, a board with relatively high type, $\theta_B > \mathbb{E}[\theta]$, is not easily convinced to approve. It ratifies novel projects with expected value that is sufficiently high—this happens only following $r = h$ with a sufficiently high θ_R (region $\mathcal{P}_3$) but not otherwise (region $\mathcal{P}_4$).

CEO's reporting and presentation decisions. The CEO presents an encountered routine project if and only if the (revealed by the signal) value is at least θ_C; that is $d_s = \mathbb{1}_{s=\theta \geq \theta_C}$.[15] The more interesting case is that of a novel project: then the problem of the CEO is to choose an observable reporting cutoff θ_R and report-specific presentation decisions (d_l, d_h) that maximize her payoff. The best possible outcome from the CEO's perspective is when all novel projects with value $\theta \geq \theta_C$ are presented and approved and the ones with value $\theta < \theta_C$ are either not presented or rejected. This can be implemented by setting $\theta_R = \theta_C$ and making sure that (i) $a_l \cdot d_l = 0$ and (ii) $a_h \cdot d_h = 1$. Ensuring (i) is straightforward—all the CEO needs to do is not present the novel project if the report is low, i.e., $d_l = 0$.[16] Ensuring (ii) is more

[15] If $\theta_C < \theta_B$, routine projects with value $\theta \in [\theta_C, \theta_B)$ will be rejected—for those projects the CEO is indifferent between presenting and not presenting.

[16] More specifically, when θ_B is in problem regions $\mathcal{P}_2$–$\mathcal{P}_4$ of Figure 2, the CEO is indifferent between $d_l = 1$ and $d_l = 0$ because in any case $a_l = 0$. However, in part of region $\mathcal{P}_1$ where $\theta_R < L(\theta_C)$, the CEO *strictly* prefers not to present the project reported to have low value as otherwise the board will approve it.

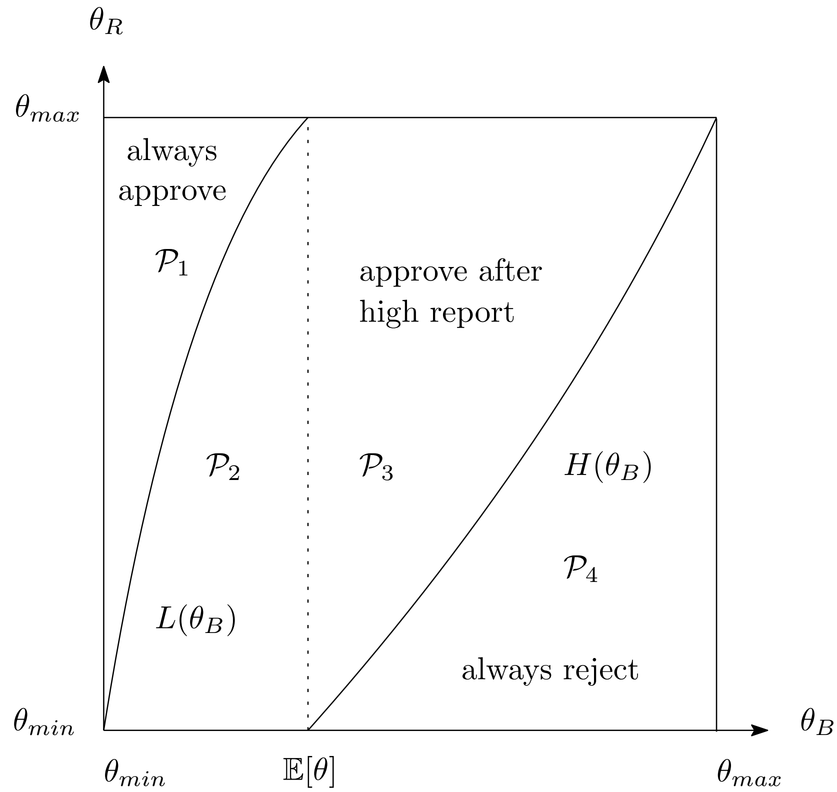


Figure 2: Board's report-specific approval of a presented novel project

challenging. The first necessary condition is that the CEO presents after observing a high report, $d_h = 1$. The second necessary condition is that the board approves after high report, $a_h = 1$. While this is the case for problem regions $\mathcal{P}_1$–$\mathcal{P}_3$ in Figure 2, it is not for $\mathcal{P}_4$. In this last region, making sure that the board approves a presented novel project with high report requires increasing the reporting cutoff to the board's indifference point, $\theta_R = H(\theta_B)$.[17]

Lemma 4 (Reporting, presentation and approval of novel projects)**.** *For novel projects, the CEO chooses a reporting cutoff* $\theta_R^* = R(\theta_B) \equiv \max\{\theta_C, H(\theta_B)\}$ *at date 2 and presents at date 3 if and only if the report is high. At date 4, the board approves the presented project.*

A board with $\theta_B < H^{-1}(\theta_C)$ faces a reporting cutoff of $\theta_R^* = \theta_C < \theta_S$ and approves all novel projects favored by the CEO; such board overinvests from the shareholders' perspective

[17] In equilibrium, the board approves the presented novel project. This is due to the CEO's full control over the collected information about novel projects. If the board could discover the value of a novel project with some probability q then, whenever the board discovers $\theta \in (\theta_R, \theta_B)$, it would reject the project—that is, the board would not simply "rubber-stamp" the CEO's proposals. If the probability q is independent of the CEO's signal, the rest of our results remain qualitatively similar.

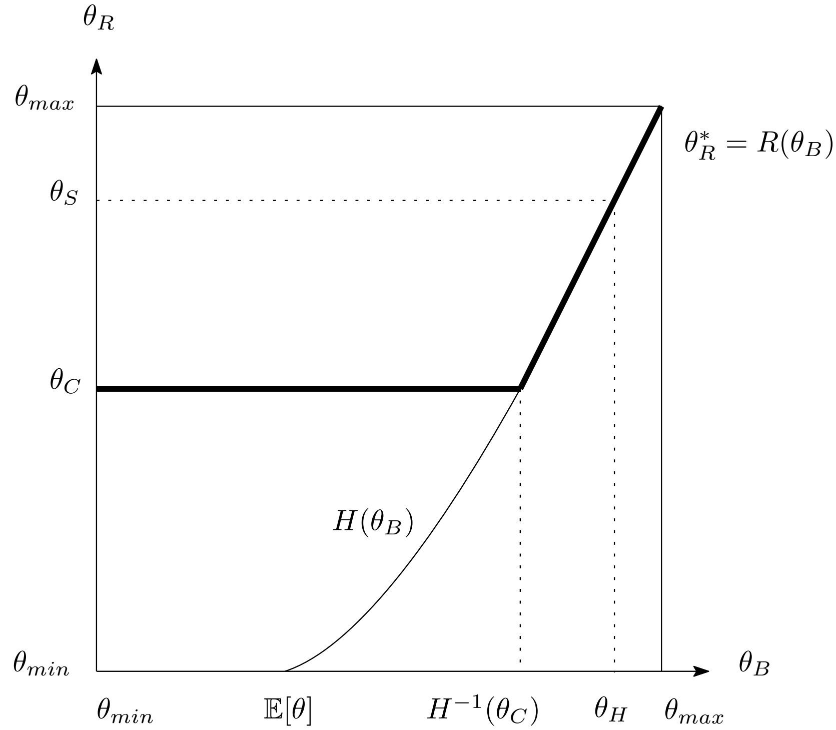


Figure 3: Optimal reporting cutoff of a novel project (in bold line)

(Figure 3). As θ_B increases beyond $H^{-1}(\theta_C)$, the reporting cutoff also increases: the board now approves fewer novel projects and is less likely to overinvest. When the board has a sufficiently conservative bias, $\theta_B = \theta_H \equiv H^{-1}(\theta_S) > \theta_S$, it faces cutoff $\theta^*_R = \theta_S$ and invests efficiently in innovations. Any board with $\theta_B > \theta_H$ underinvests as then $\theta^*_R > \theta_S$.

Corollary 1. *The CEO's optimal reporting cutoff about novel projects is (weakly) increasing in θ_B and θ_C and is independent of θ_S. There exists a unique value $\theta_H = H^{-1}(\theta_S) > \theta_S$, such that a board with bias $\theta_B < \theta_H$ approves some shareholder-value-destroying novel projects and a board with bias $\theta_B > \theta_H$ rejects some shareholder-value-enhancing ones.*

Before we analyze the board bias that maximizes firm value, we briefly summarize the outcomes for routine and novel projects. Given that both players have veto over the project, the firm undertakes all routine projects with value $\theta \geq \max\{\theta_C, \theta_B\}$ and all novel projects with value $\theta \geq \theta^*_R = R(\theta_B) = \max\{\theta_C, H(\theta_B)\}$. Efficient investments for routine projects are thus achieved when the board is neutral ($\theta_B = \theta_S > \theta_C$) and for novel ones—when the board is strongly conservative ($\theta_B = \theta_H > \theta_S > \theta_C$). One can draw a parallel to the benchmark setting, where the CEO's empire-building and opportunistic reporting are curbed via a commitment to a sufficiently high hurdle rate. In contrast, here, the same disciplining effect is achieved by a conservative bias. This observation implies that commitment and bias serve as substitutes in influencing CEO behavior.

Optimal board bias. Taking into account the reporting, presentation and approval decisions, the optimal board bias from the shareholders' perspective, which we denote by $\widetilde{\theta}_B^*$, maximizes the shareholders' welfare $W(\theta_B) \equiv pW^{routine}(\theta_B) + (1-p)W^{novel}(\theta_B)$, i.e., a convex combination of the firm value in case of routine projects, $W^{routine}(\theta_B) \equiv \int_{\max\{\theta_C,\theta_B\}}^{\theta_{max}}(\theta-\theta_S)g(\theta)d\theta$, and the firm value in case of novel projects, $W^{novel}(\theta_B) \equiv \int_{\theta_R^*}^{\theta_{max}}(\theta-\theta_S)f(\theta)d\theta$. It is easy to see from our analysis in the preceding section that the ex-ante optimal board has a bias between θ_S and θ_H. Any other bias is associated with prohibitively large investment inefficiencies: an expansionist board with $\theta_B < \theta_S$ overinvests and a conservative board with $\theta_B > \theta_H$ underinvests *in both routine and novel projects.* This observation allows us to focus solely on the interval $[\theta_S, \theta_H]$ (to which we refer to as "the relevant" interval) and streamline the analysis in this section.

In the relevant interval, $W^{routine}(\theta_B)$ is a decreasing function: intuitively, an increase in the board's type beyond θ_S leads to underinvestment in routine projects and, thereby, a decrease in firm value. To analyze the shape of $W^{novel}(\theta_B)$, it is instructive to classify boards into two subsets, depending on the intensity of their conflict of interest with the CEO.

Definition 1 (Conflict of interest)**.** *The conflict of interest between a board with bias θ_B and a CEO with bias θ_C is weak if $\theta_B < H^{-1}(\theta_C)$ and strong otherwise.*

An increase of θ_B in the region of weak conflict has no effect on the reporting cutoff and the novel project decision: the CEO continues to set $\theta_R = \theta_C$ and the board continues to approve all novel projects with value above this cutoff. As a result, in the region of weak conflict $W^{novel}(\theta_B)$ remains constant. In contrast, an increase of θ_B in the region of strong conflict increases the reporting cutoff, reduces overinvestment, and raises $W^{novel}(\theta_B)$.[18]

[18]Note that $W^{novel}(\theta_B)$ is increasing only in the interval $[H^{-1}(\theta_C), \theta_H]$. An increase of θ_B beyond θ_H leads to underinvestment and decreases $W^{novel}(\theta_B)$; this however is outside the relevant interval under consideration.

The preceding discussion implies that an increase of θ_B in the region where the conflict between the board and the CEO over novel projects is weak is associated with a decrease of welfare $W(\theta_B)$ because the shareholders only incur a "cost" from deterioration in decisions about routine operations. However, in the region where the conflict is strong, the shape of $W(\theta_B)$ depends on the relative magnitude of deterioration in routine projects and a "benefit" from improved decisions about novel projects. As a result, the shareholders' welfare is not necessarily single-peaked. This significantly complicates the identification of the optimal board. We proceed in two steps. First, in Lemma 5, we show that only two types of boards could be optimal: neutral and conservative. Second, in Proposition 1, we describe necessary conditions on primitives for either of these types to be optimal.

Lemma 5 (Candidates for optimal board)**.** *The optimal board is: (i) conservative and in a strong conflict with the CEO, i.e.,* $\widetilde{\theta}_B^* \in (\theta_S, \theta_H)$ *with* $\widetilde{\theta}_B^* > H^{-1}(\theta_C)$*; or (ii) neutral and in a weak conflict with the CEO, i.e.,* $\widetilde{\theta}_B^* = \theta_S$ *with* $\widetilde{\theta}_B^* < H^{-1}(\theta_C)$*.*

The candidate board in Lemma 5 part (i) has an interior bias between θ_S (the bias that ensures efficient routine investments) and θ_H (the bias that ensures efficient novel investments). This is intuitive if the shareholders' welfare—a convex combination of the firm value in case of routine projects and that in case of novel projects—is single-peaked which, as previously noted, is not always guaranteed. Notably, the candidate in part (i) has to be in a *strong conflict* with the CEO to induce reporting cutoff $\theta_R > \theta_C$.

What happens when the shareholders welfare is not single-peaked? This is the scenario in part (ii) of Lemma 5 which establishes that a neutral board ($\theta_B = \theta_S$) may be optimal; yet a strongly conservative board ($\theta_B = \theta_H$) may not. The intuition behind this is as follows: A change from strongly conservative board mitigates underinvestments, whereas a change from neutral board does not mitigate overinvestments if the conflict between the CEO and neutral board is weak. This property makes neutral boards locally optimal.

Three implications of Lemma 5 stand out. First, optimal neutral boards are associated with weak conflicts and optimal biased boards with strong conflicts. Second, the shareholders always face inappropriate approvals of novel projects (because $\widetilde{\theta}_B^* < \theta_H$) and may face inappropriate rejections of routines (because $\widetilde{\theta}_B^* \geq \theta_S$). Put differently, in equilibrium, investments in routine projects are either efficient or insufficient, but investments in novel projects are always excessive. Third, we predict that the distribution of optimal boards is *bimodal* in the exogenous characteristics of the investment opportunities, directors and CEOs as companies can be classified into those with optimally neutral boards and those with optimally conservative ones.

The conditions for optimality depend on the parameters, and especially on the probability p and the distributions F and G. Without imposing additional restrictions, we can only formulate necessary conditions on primitives for the optimality of each of the two candidate board types:[19]

Proposition 1 (Conditions for optimality of the board candidates)**.**

(i) A necessary condition for the optimal board to be neutral is that the latter is in a weak conflict with the CEO, i.e., $\theta_S < H^{-1}(\theta_C)$.

(ii) A necessary condition for the optimal board to be biased against project approval is that

$$(1-p)\left[W^{novel}(\theta_H) - W^{novel}(\theta_S)\right] \geq p\left[W^{routine}(\theta_S) - W^{routine}(\max\{\theta_S, H^{-1}(\theta_C)\})\right].$$

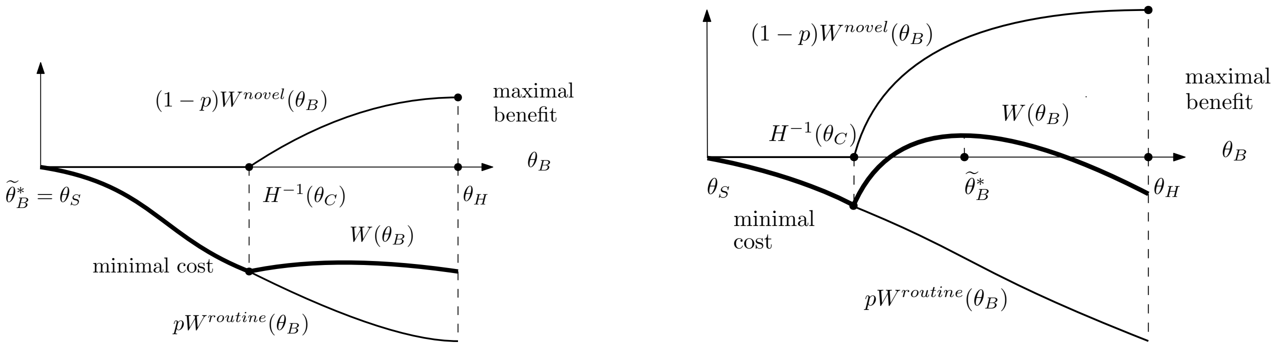
To intuition behind (i) is straightforward: if this condition is violated the reporting cutoff set by the CEO is $\theta_R = H(\theta_S) > \theta_C$. In this case, the neutral board can not be optimal as making it more conservative (by increasing the bias beyond θ_S) alleviates overinvestment in novel projects (by pushing the reporting cutoff closer to the one most favored by the shareholders). To understand condition (ii), note that the right hand side of the inequality represents the expected minimal loss from distortions in routine projects committed by a conservative board—accordingly, we refer to it as "the minimal cost of establishing a strong

[19] Note that when condition (i) is violated—so that a neutral board is in a strong conflict with the CEO—condition (ii) is met: if $R(\theta_S) > \theta_C$, then $\max\{\theta_S, H^{-1}(\theta_C)\} = \theta_S$, and so the right hand side of the inequality is zero while the left hand side is positive. However, when condition (i) is met—so that a neutral board is in a weak conflict with the CEO—condition (ii) may or may not be violated: now $R(\theta_S) = \theta_C$ implies $\max\{\theta_S, H^{-1}(\theta_C)\} = H^{-1}(\theta_C) > \theta_S$. Thus, three scenarios may occur.

conflict with the CEO." The left hand side of the inequality represents the ex-ante gain from alleviating distortions in novel projects thanks to a strongly biased board that can undo the CEO's empire-building ($\theta_B = \theta_H$), compared with a neutral board. Because this is the maximum gain that can be achieved by a conservative board, we refer to it as "the maximal benefit from establishing a strong conflict with the CEO." For a biased board to ever be optimal, the maximal benefit that shareholders can gain has to exceed the minimal cost. An alternative way to describe this condition is to say that the cost of switching from a weak to a strong conflict, measured by the loss from distorted decisions on routine operations, should not be prohibitively large.

To gain further intuition about Proposition 1 consider a neutral board that is in a weak conflict with the CEO. A small increase in θ_B does not affect approved novel projects, as the CEO continues to set the reporting cutoff at θ_C, but distorts approved routine projects, as some projects with value $\theta > \theta_S$ are rejected. As long as $\theta_B < H^{-1}(\theta_C)$, the shareholders only incur costs from distorted approvals of routines without gaining benefits related to novel projects. However, an increase in θ_B beyond $H^{-1}(\theta_C)$—resulting in a switch from weak to strong conflict—raises the quality of approved novel projects. For the optimal board to be biased, it is necessary that the cumulative cost of achieving a strong conflict (minimal cost) be smaller than the benefit in eliminating all distortions in novel projects (maximal benefit). Figure 4 panel (a) illustrates a case where the minimal cost is prohibitively large so that the inequality in condition (ii) is violated. In this case, the shareholders' welfare (in bold) for a board with $\theta_B \neq \theta_S$ is lower than the welfare with a neutral board—thus, the optimal board is neutral. In contrast, panel (b) presents a case where the maximal benefit outweighs the minimal cost—the inequality in condition (ii) is satisfied. Because this is only a necessary condition, the fact that it is satisfied still does not imply that the optimal board is biased. For this to happen, the total effect on shareholders' welfare (in bold) has to exceed the welfare with a neutral board for some θ_B. In the scenario of panel (b), this is true so that the optimal board is sufficiently (but not extremely) conservative.[20]

[20]In relation to footnote 7, if the CEO were to incur a private cost instead of a benefit (that is, if $\theta_C > \theta_S$)



(a) Condition is not satisfied
(prohibitively large minimal cost)

(b) Condition is satisfied
(maximal benefit exceeds minimal cost)

Figure 4: Evaluation of the necessary condition (ii) in Proposition 1 for biased board

Our next result identifies a condition on the frequency of routine projects, p, that determines whether the necessary condition for the optimal board to be biased is satisfied.

Corollary 2. *There exists a unique value* $p^* \in (0,1]$ *such that condition (ii) in Proposition 1 is violated when* $p > p^*$ *and satisfied otherwise.*

Intuitively, when routine projects occur with sufficiently high frequency, the expected cost from distorted decisions about routine operations is large and outweighs any expected benefit from improved decisions about novel projects. The opposite holds when routine projects are less likely—then the expected benefit exceeds the expected cost.

Condition (ii) of Proposition 1 depends also on θ_C. While we can say that the condition is more likely met when the CEO has stronger empire-building tendency, little beyond that can be said for general distributions.[21]

Before concluding our main analysis, we emphasize that the difference between a model where the board can commit to hurdle rates (benchmark case) and a model where it can not (main model) is that the outcome preferred by the shareholders is achieved with a different instrument. In the benchmark, a neutral board achieves the outcome through a hurdle rate

the optimal board bias depends on whether the CEO can veto (not present) projects or not. In the former case the optimal board is always neutral and in the latter is either neutral or has a bias with an opposite sign to the one in our current findings.

[21]While the left-hand side of the condition is independent of θ_C, the right-hand side is (weakly) increasing in θ_C for any F and G. Thus lower θ_C makes it easier for the inequality to be satisfied.

(sets the investment policy directly), whereas in the main model the shareholders achieve the outcome through board bias (i.e., they implement the investment policy indirectly).[22] Our analysis thus illustrates that the board's commitment power and the board's bias are substitutes.

5 Model Variations and Discussions

5.1 Board's Information Acquisition

In this section, we extend our results by allowing the board to acquire costly information (e.g., hire a consultant or exert an effort to learn) about the value of a presented novel project after reviewing the CEO's report on date 3.[23] Similar to the CEO's information structure, the board acquires a binary message. Formally, for any CEO's report r that induces presentation ($d_r = 1$) and implies that $\theta \in [\underline{\theta}, \overline{\theta}]$ the board chooses a cutoff $\theta_M \in [\underline{\theta}, \overline{\theta}]$ such that a message $m = b$ is generated when $\theta < \theta_M$ and a message $m = g$ otherwise. We say that the board learns if θ_M is in the interior of this interval. Otherwise, if θ_M is in a corner, the board does not learn. We assume that the board incurs an information acquisition cost $C(\theta_M, \kappa) = \kappa \cdot \Pr(a_m \neq a_r \mid r, d_r = 1)$, where $\kappa > 0$ is a cost parameter while $a_r \in \{0, 1\}$ and $a_m \in \{0, 1\}$ are the optimal pre- and post-message decisions of the board, respectively. This specification means that the cost increases in the probability of reversing pre-message decisions, i.e., the likelihood of the acquired information being useful.[24]

Lemma 6. *For any report r that induces presentation ($d_r = 1$) and implies that $\theta \in [\underline{\theta}, \overline{\theta}]$:*

(i) The board sets $\theta_M = \max\{\theta_B - \kappa, \underline{\theta}\}$ and rejects the projects with $\theta \in [\underline{\theta}, \theta_M)$ if its pre-message decision is to accept the presented novel project, $a_r = 1$.

[22] When the board can commit only to a single hurdle rate, $\rho = \rho^{novel} = \rho^{routine}$, the equilibrium outcome is the same.

[23] For routine projects, the signal s is already fully informative.

[24] In Appendix A.6, we consider entropy cost.

(ii) The board sets $\theta_M = \min\{\theta_B + \kappa, \overline{\theta}\}$ and approves projects with $\theta \in [\theta_M, \overline{\theta}]$ if its pre-message decision is to reject the presented novel project, $a_r = 0$.

Consider the case of part (i). Without further information, the board accepts the project, $a_r = 1$, which implies that $\theta_B < \overline{\theta}$ because $\mathbb{E}[\theta|r] \geq \theta_B$. If $\theta_B \leq \underline{\theta}$, the board favors all presented projects and has no incentives to learn costly further information; consequently, it optimally sets the message cutoff at $\theta_M = \underline{\theta}$. However, if $\theta_B \in (\underline{\theta}, \overline{\theta}]$, learning can be beneficial. Setting $\theta_M = \theta_B$ would yield the most useful information as it will eliminate all inappropriate from the board's perspective approvals. This, however, is costly, so the board optimally reduces the cutoff to $\theta_M = \theta_B - \kappa$ and learns imperfectly unless the cost parameter is prohibitively high, $\kappa > \theta_B - \underline{\theta}$, in which case the board sets $\theta_M = \underline{\theta}$ and does not learn.[25]

Now consider the case of part (ii), where the pre-message decision of the board is to reject the project, $a_r = 0$. For the board to be willing to reject the project, it needs to be the case that $\theta_B > \mathbb{E}[\theta|r]$, which in turn implies $\theta_B > \underline{\theta}$. If $\theta_B \geq \overline{\theta}$, it is never optimal to set an interior cutoff θ_M and learn because no project with $\theta < \overline{\theta}$ is valuable enough to be pursued from the board's point of view. It remains to consider $\theta_B \in (\underline{\theta}, \overline{\theta})$. Setting $\theta_M = \theta_B$ eliminates all inappropriate rejections but this is costly, so the board sets $\theta_M = \min\{\theta_B + \kappa, \overline{\theta}\}$ and learns imperfectly unless the cost parameter is prohibitively high, $\kappa > \overline{\theta} - \theta_B$.[26]

Next we consider the optimal binary reporting and presentation strategy of the CEO in anticipation of the board's information acquisition.

Lemma 7. *At date 2, the CEO sets $\theta_R \in [R(\theta_B), \widehat{R}(\theta_B, \kappa)]$, where $R(\theta_B) = \max\{\theta_C, H(\theta_B)\}$ as defined in Lemma 4 and $\widehat{R}(\theta_B, \kappa) \equiv \max\{\theta_C, H(\theta_B), \theta_B - \kappa\}$. At date 3, the CEO presents the novel project with $r = h$, and the board sets $\theta_M = \widehat{R}(\theta_B, \kappa)$. At date 4, the board approves projects with $\theta \geq \theta_M$ and rejects the rest.*

On the one hand, if the CEO sets the reporting cutoff at the level that is optimal without board's learning, i.e., $\theta_R = R(\theta_B)$ as defined in Lemma 4, the board may acquire further

[25] It is never optimal for the board to set $\theta_M > \theta_B$. In contrast to $\theta_M = \theta_B$, this leads to inappropriate rejections of projects with $\theta \in [\theta_B, \theta_M)$ and imposes a higher cost.

[26] Here, it is not optimal for the board to set $\theta_M < \theta_B$. In contrast to $\theta_M = \theta_B$, this leads to inappropriate approvals of projects with $\theta \in [\theta_M, \theta_B)$ and imposes a higher cost.

information (Lemma 6). On the other hand, by setting $\theta_R = \widehat{R}(\theta_B, \kappa)$ the CEO provides *exactly* the same information that the board may choose to acquire at a cost—in such a case, it would be irrational for the board to learn.[27] So what is the CEO's choice? It turns out that the CEO is indifferent between setting any $\theta_R \in [R(\theta_B), \widehat{R}(\theta_B, \kappa)]$. Either of these types yields an identical outcome for the CEO, with the only difference being the cost incurred by the board.[28]

The natural follow-up question is what type of board invests efficiently in novel projects? From the shareholders' perspective, the most desired outcome for novel projects is when the board has a type $\widehat{\theta}_H = \widehat{R}^{-1}(\theta_S; \kappa) = \min\{H^{-1}(\theta_S), \theta_S + \kappa\}$. It is easy to see that this is weakly below $\theta_H = H^{-1}(\theta_S)$; that is, the board with a learning option that invests efficiently in novel projects is less conservative than the one without a learning option. Notably, when κ is lower, $\widehat{\theta}_H$ is lower. This implies that the CEO's opportunistic reporting is mitigated either by appointing a more conservative board or by improving the board's access to information—in our model, the two are substitutes. Does the introduction of a learning option always mitigate investment inefficiencies? Our next result shows that this is surprisingly not always the case, at least for a given board type.

Lemma 8. *For given θ_B, the introduction of learning option mitigates investment distortions if $\theta_B \in [\theta_{min}, \widehat{\theta}_H]$ and amplifies investment distortions if $\theta_B \in [\theta_H, \theta_{max}]$. If $\theta_B \in (\widehat{\theta}_H, \theta_H)$, investment distortions for $\theta < \theta_S$ are eliminated but new distortions for some $\theta > \theta_S$ are introduced.*

Before concluding, we comment on how learning affects the optimal board type. Now the interval of relevant board biases is narrower, $[\theta_S, \widehat{\theta}_H] \subseteq [\theta_S, \theta_H]$. In addition, for any relevant board bias, the firm value in the case of a novel project increases from $W^{novel}(\theta_B) =$

[27] The main driving force behind the ability of the CEO to prevent the board from learning is that the CEO knows κ. In Appendix A.5 we extend our results to a case where κ is unknown. Our main results about the optimal board bias remain robust.

[28] The reporting cutoff is uniquely optimal only if $R(\theta_B) = \widehat{R}(\theta_B, \kappa)$, or equivalently, if $\max\{\theta_C, H(\theta_B)\} \geq \theta_B - \kappa$. This happens when κ is sufficiently large. In contrast, whenever κ is sufficiently small, multiple reporting cutoffs are optimal.

$\int_{R(\theta_B)}^{\theta_{max}}(\theta - \theta_S)f(\theta)d\theta$ to $\widehat{W}^{novel}(\theta_B) \equiv \int_{\widehat{R}(\theta_B,\kappa)}^{\theta_{max}}(\theta - \theta_S)f(\theta)d\theta$. These changes do not affect qualitatively our findings that there are only two candidates for the optimal board.

Proposition 2. *High learning cost, κ, increases the likelihood that the optimal board is neutral.*

High κ increases the minimal cost of establishing a strong conflict between the CEO and the board while keeping the maximal benefit of a biased board constant. Thus the necessary condition for a conservative board to be optimal is more likely violated; the board is more likely neutral. The effect of κ on $\widehat{\theta}_B^*$ when the optimal board is already conservative is ambiguous. Nevertheless, the asymptotic effects are clear: as $\kappa \to \infty$, the optimal board type converges to the level without learning, $\lim_{\kappa\to\infty} \widehat{\theta}_B^* = \widetilde{\theta}_B^* \geq \theta_S$, whereas as $\kappa \to 0^+$, the board sets $\theta_M = \theta_B$ and so it is best for it to be neutral, $\lim_{\kappa\to 0^+} \widehat{\theta}_B^* = \theta_S$. Overall, as learning cost decreases, (i) it becomes *more likely* that conservative bias is optimal, but (ii) the bias level *decreases* asymptotically. Together, observations (i) and (ii) imply that the optimal board type might be *nonmonotonic*.[29] Taking into account that low κ can be interpreted as higher board's expertise, observation (i) reflects complementarity between bias and expertise, whereas observation (ii) reflects substitution of board bias and expertise.

5.2 Discussion of Other Extensions

Project-category-dependent bias. In the main model, we assume that there is only one board in charge of all investment opportunities, and its bias does not depend on the project category (routine or novel). This is consistent with the board bias reflecting benefits, costs, or inherent attitudes toward company expansion that do not depend on the nature of the project. If the board's preferences were to depend on the project category—i.e., bias $\theta_B^{routine}$ for routine projects and bias θ_B^{novel} for innovations—then, the discussion following Corollary 1 implies that the optimal board would be strongly conservative about novel projects (with

[29]For example, consider a set of parameters such that the optimal board is neutral without learning (for any $\kappa > \theta_{max}$) but, because of observation (i), is biased with learning (for interior κ). By observation (ii), as $\kappa \to 0^+$, the optimal board type converges back to neutral.

$\theta_B^{novel} = \theta_H$) and aligned with the shareholders about routine ones (with $\theta_B^{routine} = \theta_S$).[30]

Delegation of approval decisions. Consistent with empirical evidence that management is tasked with searching and boards with ratification of significant opportunities (Useem 2006), we take the delegation of approval to the board as given in the main model. This also aligns with recent empirical evidence that more emphasis is given to the board's monitoring role (Faleye, Hoitash, and Hoitash 2011). Our analysis in Section 4 implies that it is clearly suboptimal to delegate the decisions about all projects to the CEO or delegate the decisions about novel projects to the CEO and those about routine projects to the board. The only alternative division of approval powers that could be considered then is to delegate the decision about routine projects to the CEO and have a board specialized in novel projects. Under this scenario, the forces at play in our model are reinforced, and the optimal board is strongly conservative.

6 Concluding Remarks

We study the optimal bias of corporate boards tasked with approving investment opportunities proposed by empire-building CEOs. In line with the empirical evidence (Maffett, Nakhmurina, and Skinner 2022), we find that reducing the alignment of interests between CEOs and boards (that lack the ability to commit to approval policy) may improve investment efficiency due to the novel force explored in this paper. Accounting for the heterogeneity of project nature, we also predict a bimodal distribution of boards in the economy: a peak where boards are neutral (aligned with shareholders) and a peak where they are strongly conservative (expansion-cautious). We expect that optimal boards in firms with a large share of novel projects and managed by CEOs with strong aspirations toward empire-building are less likely neutral. Our model also predicts that firms overinvest in novel projects and some-

[30]Related, if the board bias was not project-category-dependent but the shareholders could nominate two specialized boards or even entirely spin off the innovations to a separate entity (intrapreneurship), then it would be optimal to have a neutral board for routine projects and a board that is highly conservative for innovations.

times underinvest in routine operations. The effect of directors' expertise is nontrivial: We anticipate that boards with higher expertise are more likely to be conservative (but we do not expect them to be *strongly* conservative). Our results provide testable predictions about the link between board composition and investment efficiency.

Our paper also illuminates the ongoing debate about board independence. Prior analytical research suggests that CEOs are less forthcoming about exogenously acquired non-verifiable information when faced with directors whose preferences are not aligned with theirs—a finding that may raise concerns about unintended consequences of regulations mandating a minimum number of independent directors or enabling activists to intervene, such as by electing directors with a cost-cutting agenda (e.g., the SEC's 2021 Universal Proxy Rules for Director Elections). We show that CEOs prefer to commit to gathering and communicating verifiable rather than non-verifiable information. Because, in this case, nominating a neutral or conservative board is optimal for shareholders, our study highlights the positive effect of such requirements.

Appendix

A Supplemental Analysis

A.1 Project Search

In this supplemental analysis, we extend our main results to a scenario where management is not restricted to the first encountered project. At date 1 (before the report is generated or the project value is observed), the CEO has a cost-free option to make additional independent draws from the pool of investment opportunities and search until she finds a project of the category (routine or novel) that she prefers.[31]

The board's approval and the CEO's reporting and presentation decisions remain as before. At date 1, the CEO searches for a novel project if her margin from novel project, $M(\theta_B) \equiv \mathbb{E}[(\theta - \theta_C)\mathbb{1}_{\theta \geq R(\theta_B)}|novel] - \mathbb{E}[(\theta - \theta_C)\mathbb{1}_{\theta \geq \max\{\theta_C, \theta_B\}}|routine]$, is at least zero and searches for a routine project otherwise.

Proposition 3 (Optimal board with first-order stochastic dominance)**.**

(i) If F and G are identical or if F first-order stochastically dominates G, then $\theta_B^* = \theta_H$ and the CEO pursues a novel project.

(ii) If G first-order stochastically dominates F:

- *when $M(\theta_S) < 0$, then $\theta_B^* = \theta_S$ and the CEO pursues a routine project;*
- *when $M(\theta_S) \geq 0$, then $\theta_B^* \neq \theta_S$ and $\theta_B^* \notin [\theta_{min}, \theta_C]$.*

Because of her ability to opportunistically choose the reporting cutoff of novel but not routine projects, the CEO is more willing (than the shareholders) to pursue novel projects, all else equal.[32] As a result, when the values of the projects follow the same distribution or when the value of novel projects (first-order) stochastically dominates that of routines, as is the case of Proposition 3 (i), the preferences of the board and the CEO about project category are aligned at $\theta_B = \theta_H$. Thus the optimal board has a bias of $\theta_B^* = \theta_H$, and the CEO pursues a novel project. Because the board can fully undo the CEO's empire-building, the equilibrium investment is efficient. When the value of routine projects stochastically dominates that of novel ones, two scenarios may arise. If the players' preferences at $\theta_B = \theta_S$ about project selection are aligned, as is the case of Proposition 3 (ii), the CEO searches for a routine project, the optimal board is neutral, $\theta_B^* = \theta_S$, and the equilibrium investment is efficient. However, if $M(\theta_S) \geq 0$ so that the preferences at $\theta_B = \theta_S$ are misaligned, the optimal board can never be neutral. This is intuitive: when faced with a neutral board, the CEO pursues a novel project. However, conditional on the project being novel, a neutral board is suboptimal for the shareholders.

[31] This is equivalent to a single draw with setting the probability p to be either zero (when novel project is preferred) or one (when routine project is preferred).

[32] The CEO's margin is $M(\theta_B) = W^{novel}(\theta_B) - W^{routine}(\theta_B) + (\theta_S - \theta_C)[G(\max\{\theta_B, \theta_C\}) - F(R(\theta_B))]$. The misalignment of preferences about project selection arises because of the third term, which reflects the difference in probability of obtaining a private benefit $\theta_S - \theta_C$ by the CEO.

So what is the optimal board in scenario (ii) with $M(\theta_S) \geq 0$? There are two options. First, the shareholders could acquiesce to the CEO's tendency to pursue a novel project and nominate a conservative board to counteract empire-building. Second, the shareholders could persuade the CEO to search for a routine project by nominating a board whose bias makes the pursuit of routine projects attractive from the CEO's perspective. The best option depends on the relative magnitude of the shareholders' benefit from pursuing a routine (stochastically dominating) project, rather than a novel (stochastically dominated) one, and the shareholders' loss from investment distortions by a board that is biased enough to influence the CEO's project selection. Due to the generality of our model, there is little we can say about the board that sways the CEO into pursuing a routine project, apart from it not being neutral (as argued above) or having stronger pro-expansion bias than the CEO (as this introduces investment distortions that can be mitigated by a different board).[33]

A.2 Alternative Report Structures

In the main model we focus on a binary reporting structure where $r = l$ is reported when $\theta \in [\theta_{min}, \theta_R]$ and $r = h$ when $\theta \in [\theta_R, \theta_{max}]$. There, we briefly explain that this is one of the optimal reporting structures and no other structure can achieve a strictly better outcome for the CEO. We now show that this is indeed the case.

When the model parameters are such that the CEO chooses $\theta_R = \theta_C \geq H(\theta_B)$, the proof is trivial since the binary report implements the CEO's first-best outcome. Let us now focus on the case where the model parameters are such that the CEO sets $\theta_R = H(\theta_B) > \theta_C$. In this case the board is exactly indifferent over project acceptance and rejection when $r = h$.

Consider an alternative reporting structure where the continuum $[\theta_{min}, \theta_{max}]$ is split into n adjacent intervals indexed in an ascending order $i = 1, \ldots, n$. A report $r = i$ is realized when $\theta \in [\underline{\theta}_i, \overline{\theta}_i]$. The CEO chooses the number of intervals n and the corresponding cutoffs $\underline{\theta}_i$ and $\overline{\theta}_i$. The posterior project value conditional on report $r = i$ is increasing in i, and therefore the reports can be divided into reports that induce $a = 0$ (the project is rejected because the posterior is insufficient, $\mathbb{E}[\theta|\theta \in [\underline{\theta}_i, \overline{\theta}_i]] < \theta_B$) and reports that induce $a = 1$ (the project is accepted because the posterior is sufficient, $\mathbb{E}[\theta|\theta \in [\underline{\theta}_i, \overline{\theta}_i]] \geq \theta_B$).

We prove that this information structure cannot be better for the CEO. First of all, see that the posterior project value on the interval $[\underline{\theta}_i, \overline{\theta}_i]$, $\mathbb{E}[\theta|\theta \in [\underline{\theta}_i, \overline{\theta}_i]]$, is increasing in both $\underline{\theta}_i$ and $\overline{\theta}_i$. Take the *lowest* report out of all reports that generate a sufficiently large posterior and denote it k. (If no such report exists, the information structure is clearly worse as the project is rejected for any θ.) If the richer information structure is better for the CEO than the binary structure, then we must have $\underline{\theta}_k < \theta_R = H(\theta_B)$. Since $\underline{\theta}_k < \theta_R$ and $\overline{\theta}_k \leq \theta_{max}$, the board's posterior project value for a report k in the richer structure is *lower* than the board's project value for a report h in the binary structure, $\mathbb{E}[\theta|\theta \in [\underline{\theta}_k, \overline{\theta}_k]] < \mathbb{E}[\theta|\theta \in [\theta_R, \theta_{max}]] = \theta_B$.

[33] One could design conditions under which the optimal board has a mild pro-expansion bias to sway the CEO into selecting a routine project. This, for example, can occur if (i) $M(\theta) > 0$ for any $\theta \in [\theta_S, \theta_H]$; and (ii) $W^{routine}(\theta_C) > \max\{W^{novel}(\theta_H), W^{routine}(\theta_H)\}$ hold simultaneously. In this case, the optimal board has $\theta_B^* \in (\theta_C, \theta_S)$, and the CEO selects a routine project in equilibrium. To see why, note that the imposed condition (i) rules out the possibility that the CEO selects a routine project when faced with $\theta_B \in [\theta_S, \theta_H]$. Moreover, the imposed condition (ii) rules out the optimality of any board with $\theta_B > \theta_H$ but also ensures that the board prefers to sway the CEO into selecting a routine project. Lastly, by Proposition 3, the board cannot have a (weakly) stronger pro-expansion bias than that of the CEO.

Since $\mathbb{E}[\theta|\theta \in [\underline{\theta}_k, \overline{\theta}_k]] < \theta_B$, the board that observes $r = k$ rejects the project. This is a contradiction.

Finally, while a richer information structure cannot give the CEO a higher payoff, it can give an identical payoff. First, it is always possible to refine the low report $r = l$ by setting any number of intervals for the continuum $[\theta_{min}, \theta_R^*]$, but the CEO will still decide to not present the project with the refined (more precise) information. Second, when $\theta_R = \theta_C > H(\theta_B)$, it is possible to refine $r = h$ as long as the lowest report out of all reports that generate a sufficiently large posterior satisfies $\underline{\theta}_k = \theta_C$. When $\theta_R = H(\theta_B) \geq \theta_C$, it is never optimal to refine the high report $r = h$. See also Friedman, Hughes and Michaeli (2020) for weak optimality of binary report structures with threshold payoffs (similar to the ones obtained when the receiver takes a binary action as in our setting).

A.3 Cheap Talk

In the main analysis, we solely focus on the CEO's collection of publicly observable information. In practice, after preparing a formal report for a board meeting, CEOs may come across additional information and informally communicate it to the board. In this extension, we briefly demonstrate that our main results are robust to accounting for such a possibility. In particular, we consider a setting where, after the public report is observed and the project is proposed, the CEO privately learns the novel project value and sends a non-verifiable message to the board (cheap talk communication). The timing of the public report realization does not matter.

Proposition 4 (Robustness of the results with cheap talk)**.** *Suppose that, after the public report is observed and the project is proposed, the CEO privately learns the novel project value and sends a non-verifiable message to the board. Then, the CEO's equilibrium non-verifiable message is uninformative, and the equilibrium reporting cutoff is $\theta_R^* = R(\theta_B)$ as defined in Lemma 4.*

In equilibrium, the post-report cheap talk communication is uninformative and has no effect on the CEO's reporting strategy.[34] Put differently, the presence of cheap talk option preserves the communicated hard information without conveying additional soft information. Our analysis implies that the CEO at least weakly prefers committing to verifiable messages and opting out of subsequent non-verifiable communication. Given Proposition 4, the findings in the main model remain intact even when the CEO privately learns the novel project value (after setting the reporting cutoff) and sends a non-verifiable message to the board.[35]

A.4 Private Reports and Misreporting

We now consider an extension where the CEO privately observes the report r about a novel project and communicates a message $m_r \in \{l, r\}$ to the board. If the CEO misreports, i.e., $m_r \neq r$, she incurs a non-negative cost $\gamma \geq 0$.

[34]Essentially, the CEO's message only confirms that the project value belongs to the subinterval associated with the realized report.

[35]If we additionally alter the main model such that the CEO *cannot choose the properties of the publicly observable report* and can only send a non-verifiable message to a board that takes a binary action (accept/reject), the optimal board from shareholders' perspective would be neutral. Analysis available upon request.

We note that if $\theta_B < \theta_C$ the CEO obtains her most preferred outcome by setting $\theta_R = \theta_C$ and presenting only projects with $r = h$. The possibility to misreport in this case has no impact as the CEO, having observed any r, has no incentives to deviate from $m_r = r$ and $(d_l, d_h) = (0, 1)$.

Next we turn to the more interesting case $\theta_B \geq \theta_C$. If $\theta_B \leq \mathbb{E}[\theta]$, the board that believes $r = h$ approves the project for any reporting cutoff $\theta_R \geq \theta_C$.[36] However, if $\theta_B \geq \mathbb{E}[\theta]$, ensuring board's approval when the board believes $r = h$ imposes a lower bound $\theta_R \geq H(\theta_B)$ on the reporting cutoff. Lemma 4 in the main text showed that, with public reports, this is the only constraint. When the report is private, the board still has to be motivated to approve a presented project, $\theta_R \geq H(\theta_B)$, but the CEO's communication of $m_r = r$ is no longer guaranteed. There are two candidates for an equilibrium in the subgame starting at date 2. The first is a separating equilibrium where a CEO who has observed $r = h$ sends $m_h = h$ and presents the project, and a CEO who has observed $r = l$ sends $m_l = l$ and does not present the project. If this separating equilibrium fails to exist due to deviation of any type, then the only equilibrium in the subgame starting at date 2 is a pooling equilibrium. In this pooling equilibrium, the board ignores all CEO messages and approves or rejects the proposed project based on its prior beliefs, $\mathbb{E}[\theta] \lesseqgtr \theta_B$.

When $\theta_R \geq \theta_C$, a CEO who has observed $r = h$ strictly prefers to communicate $m_h = h$. But a CEO who has observed $r = l$ may misreport. There exist a reporting cutoff at which, following $r = l$, the CEO is indifferent between project rejection (via costless message $m_l = l$) and project approval (via costly misreporting $m_l = h$). This indifference writes

$$\mathbb{E}[\theta|\theta \leq \theta_R] - \theta_C - \gamma = 0$$

and is equivalent to board's indifference over the two outcomes, where the board type is $\theta_B = \theta_C + \gamma$. Using our established notation, this indifference holds for a reporting cutoff $\theta_R = L(\theta_C + \gamma)$. If the reporting cutoff is higher, the expected project value after $r = l$ is too attractive for a CEO who has observed $r = l$, and she misreports. Therefore, the CEO of type $r = l$ is willing to communicate $m_l = l$ and withhold the project, $d_l = 0$, only if the reporting cutoff complies with an upper bound

$$\theta_R \leq L(\theta_C + \gamma).$$

Note that $\theta_C < L(\theta_C) \leq L(\theta_C + \gamma)$. Therefore, only two situations exist:

(i) If $\max\{\theta_C, H(\theta_B)\} \leq L(\theta_C + \gamma)$, the upper bound is loose at $\theta_R^* = \max\{\theta_C, H(\theta_B)\}$. An informative equilibrium with a reporting cutoff $\theta_R^* = \max\{\theta_C, H(\theta_B)\}$, messages $(m_l, m_h) = (l, h)$, presentation decisions $(d_l, d_h) = (0, 1)$, and approval $a_h = 1$ exists.

(ii) If $\theta_C < L(\theta_C + \gamma) < H(\theta_B)$, there is no reporting cutoff θ_R that simultaneously satisfies the lower and the upper bound. The equilibrium is uninformative. Because this situation occurs only when the lower bound restricts the CEO's implementation of cutoff θ_C (i.e., when $H(\theta_B) > \theta_C$), we must have that $H(\theta_B) > \theta_C > \theta_{min}$ which implies $\theta_B \geq \mathbb{E}[\theta]$ (see also Figure 3), and so after an uninformative message the board *rejects* the project.

[36] Lower reporting cutoffs are irrelevant as the conflict of interests between the CEO and the shareholders exists only on the interval $\theta_R \in [\theta_C, \theta_S]$.

We next consider the board type that maximizes firm value *if the project is novel with certainty*. In the main setting, this board has type $\theta_B^* = \theta_H$. We are interested in finding how the introduction of private reports changes this prediction. We assume that whenever the shareholders are indifferent between multiple board types, they choose the highest one. As our result below shows, the key consideration is whether the upper bound on θ_R is binding for a board of type $\theta_B = \theta_H$ or not. For the sets of parameters where this constraint is loose, the introduction of private reports does not change the outcome, $\theta_B^* = \theta_H$, and investments are efficient. For the set of parameters where this constraint is binding, the optimal board is still conservative but can be either more mildly biased $\theta_B^* \in (\theta_S, \theta_H)$ or extremely biased $\theta_B^* = \theta_{max} > \theta_H$, as per our tie-breaking rule. Consequently, we either observe overinvestment or extreme underinvestment (all projects are rejected).

Proposition 5. *Suppose that the project is novel with certainty. The optimal board from a shareholders' perspective is conservative, $\theta_B^* \in (\theta_S, \theta_{max}]$. In particular:*

- *If $L(\theta_C + \gamma) \geq \theta_S$, then $\theta_B^* = \theta_H$. The investment in the novel project is efficient.*
- *If $L(\theta_C + \gamma) < \theta_S$, then:*
  - *(i) $\theta_B^* = H^{-1}(L(\theta_C + \gamma)) \in (\theta_S, \theta_H)$ if $\theta_S \leq \mathbb{E}[\theta]$ or $\theta_S > \mathbb{E}[\theta]$ and $L(\theta_C + \gamma) \geq H(\theta_S)$. The investment in the novel project is mildly excessive.*
  - *(ii) $\theta_B^* = \theta_{max} > \theta_H$ if $\theta_S > \mathbb{E}[\theta]$ and $L(\theta_C + \gamma) < H(\theta_S)$. The novel project is rejected.*

The preceding discussion focused on the case where the project is novel with certainty. Given that the optimal board then is still conservative, accounting for the possibility that the project is routine with some probability will not qualitatively change our results from the main setting.

A.5 Board's Information Acquisition With Unknown Cost

In this supplemental analysis, we extend Section 5.1 by studying the case where κ is unknown to the CEO and is revealed to the board when it chooses θ_M on date 3. We assume that κ is drawn from some distribution with support $[\underline{\kappa}, \overline{\kappa}]$, where $\underline{\kappa} > 0$. Given that the board observes the cost when acquiring information, its optimal message cutoff is the same as the one in Lemma 6.

Because the CEO does not observe κ, she anticipates a range of possible realizations. It turns out that her optimization across these realizations is simple: Any message cutoff that is optimal for $\kappa = \overline{\kappa}$ is also optimal for $\kappa < \overline{\kappa}$, i.e., for all possible cost realizations and distributions.

Lemma 9. *At date 2, the CEO sets $\theta_R \in [R(\theta_B), \widehat{R}(\theta_B, \overline{\kappa})]$, where $R(\theta_B) = \max\{\theta_C, H(\theta_B)\}$ as defined in Lemma 4 and $\widehat{R}(\theta_B, \overline{\kappa}) \equiv \max\{\theta_C, H(\theta_B), \theta_B - \overline{\kappa}\}$. At date 3, the CEO presents the novel project with $r = h$, the board observes κ and sets $\theta_M = \widehat{R}(\theta_B, \kappa) \geq \theta_R$. At date 4, the board approves projects with $\theta \geq \theta_M$ and rejects the rest.*

From the shareholders' point of view, the message cutoff spreads across a range, $\theta_M \in [\widehat{R}(\theta_B, \overline{\kappa}), \widehat{R}(\theta_B, \underline{\kappa})]$.[37] As for the board type that invests efficiently in novel investments, the following tradeoff arises: a strongly conservative board ensures efficient investment in novel projects when κ is high but underinvests when it is low. And vice versa, a mildly conservative board invests efficiently when κ is small but overinvests when it is high. Balancing these distortions in the optimum, the board with $\widehat{\theta}_H$ overinvests when the cost is high and underinvests when the cost is low.

Lemma 10. *It holds that* $\theta_S < \min\{\theta_H, \theta_S + \underline{\kappa}\} \leq \widehat{\theta}_H \leq \min\{\theta_H, \theta_S + \overline{\kappa}\}$.

So what is the optimal board type from shareholders' perspective that takes into account that projects can be routine or novel? Adding uncertainty over information costs has no effect on the existence of a tradeoff between a neutral and a conservative board. A neutral board invests efficiently in routines but overinvests in novel projects. A conservative board underinvests in routines; for novel projects, it overinvests if the realized board cost is sufficiently large. When κ is small, it may happen that the board underinvests in novel projects.

A.6 Board's Information Acquisition With Entropy Cost

This supplemental analysis illustrates that the main result about the benefit from conservative boards remains robust to assuming entropy-based information acquisition cost. To streamline the discussion, we fix $d = 1$, focus solely on novel projects, and assume a trinary state space, $\theta \in \Theta \equiv \{\theta_1, \theta_2, \theta_3\}$ with $\theta_1 < \theta_2 < 0 < \theta_3$. As before, $\theta_S = 0$, i.e., the firm value is strictly positive only if the project yielding the highest value, θ_3, is approved (i.e., only if $\theta = \theta_3$ and $a = 1$). We assume that $\theta_C \in (\theta_1, \theta_2)$, which implies that the CEO receives a positive payoff not only if the project of the highest value, θ_3, is approved but also if the one of intermediate value, θ_2, is approved (i.e., when $\theta \in \{\theta_2, \theta_3\}$ and $a = 1$). Put differently, the CEO is biased in favor of adopting the intermediate project (her empire-building preference).

The prior probability distribution of θ is common knowledge. Formally, the prior belief is given by $\boldsymbol{\mu}^o \equiv (\mu_1^o, \mu_2^o, \mu_3^o) \in \Delta(\Theta)$, where $\mu_j^o \equiv \Pr(\theta = \theta_j)$. The CEO chooses the properties of a verifiable public report R about the project value from a finite set $\mathbb{S}$ of possible realizations. For our analysis, it is useful to denote $\phi^r \equiv \Pr(R = r)$ the probability that the realized report is r. A report realization $r \in \mathbb{S}$ induces an interim belief $\boldsymbol{\mu}^r \equiv (\mu_1^r, \mu_2^r, \mu_3^r)$, where $\mu_j^r \equiv \Pr(\theta = \theta_j \mid r)$, $j \in \{1, 2, 3\}$. To avoid clutter, we occasionally suppress the superscript r and simply use $\boldsymbol{\mu}$. Only when the realized report r becomes relevant for the analysis, we use $\boldsymbol{\mu}^r$. Because every report realization r is associated with a specific belief $\boldsymbol{\mu}^r$, the distribution $\boldsymbol{\phi} = (\phi^r)_{r \in \mathbb{S}}$ also describes the (probability) distribution of the interim beliefs.[38] The CEO can select any $\boldsymbol{\phi}$ with a finite number of report realizations as long as it satisfies the martingale (Bayes-plausibility) property, $\mathbb{E}_{\boldsymbol{\phi}}[\boldsymbol{\mu}] = \boldsymbol{\mu}^o$. The distribution $\boldsymbol{\phi}$ and the posterior beliefs $\boldsymbol{\mu}$ jointly determine the precision of the report.[39]

[37] If even the lowest cost realization is prohibitively high, the interval for reporting cutoff degenerates to a single value $R(\theta_B)$, and the board that invests efficiently in novel projects is θ_H, as in the main analysis.

[38] Specifically, ϕ^r is also the probability that the interim belief is $\boldsymbol{\mu}^r$ and so there is a one-to-one mapping between the distribution of the report and the distribution of the beliefs that the report induces.

[39] In Lemma 5, we show that an optimally set binary report achieves the same expected utility for the CEO. But, for now, we allow more than two report realizations.

After observing the realization r and forming interim belief μ^r, the board may obtain an additional signal T from a set $\mathbb{T}$ of a finite number of possible realizations. We denote $\tau^t \equiv \Pr(T = t)$ the probability that the additional signal realization is t. The properties of the additional signal are characterized by $\tau = (\tau^t)_{t\in\mathbb{T}}$. For every realization $t \in \mathbb{T}$, there are corresponding final beliefs $\mu^t \equiv (\mu_1^t, \mu_2^t, \mu_3^t)$, where $\mu_j^t \equiv \Pr(\theta = \theta_j \mid r, t)$.[40] The martingale property, $\mathbb{E}_\tau[\mu^t] = \mu$, must hold.

Learning additional information is costly to the board. We assume that the board's cost of obtaining the additional signal is proportional to the reduction of the (expected) Shannon entropy so that learning a more informative signal is costlier for the board. Formally, the Shannon entropy of the $|\Theta|$-dimensional interim belief μ (for given r and ϕ before observing t) is given by: $H(\mu) = -\sum_j \mu_j \ln \mu_j$, where $0 \ln 0 = 0$ holds by convention. The total entropy-based cost of a signal distributed by τ over a support $\mathbb{T}$ is $\sum_{t\in\mathbb{T}} \tau^t H(\mu^t)$. Then, the board's personal (entropy-based) cost of the signal T is increasing in the reduction of the expected entropy, $J(\mu, \tau) = \kappa \left\{H(\mu) - \sum_{t\in\mathbb{T}} \tau^t H(\mu^t)\right\}$, where $\kappa \geq 0$ is the marginal cost of reducing the entropy.[41] The lower κ, the easier it is for the board to learn information.

Board learning and project decision. We solve this model variation by backward induction. At date 5, for given report $r \in \mathbb{S}$ and additional signal $t \in \mathbb{T}$, the board approves the project if approval yields a higher expected payoff than rejection:

$$\mathbb{E}\left[u_B(1, \theta) \mid r, t\right] \geq \mathbb{E}\left[u_B(0, \theta) \mid r, t\right] = 0. \tag{2}$$

The approval decision depends on the report and the signal. The information from the report and the signal is summarized in the final belief μ^t, so we let $a(\mu^t)$ denote the board's approval decision for the final belief μ^t. Formally, $a(\mu^t) = \mathbb{1}\{\sum_j \mu_j^t \theta_j - \theta_B \geq 0\}$, where $\mathbb{1}$ is an indicator function.

At date 4, after observing report $r \in \mathbb{S}$ and anticipating its approval strategy, the board decides whether and how much additional information to learn. Technically speaking, the board's problem is to find a distribution τ that maximizes the board's conditionally expected payoff net of personal learning (entropy-based) costs,

$$\mathbb{E}\left[u_B(a(\mu^t), \theta) \mid r, \tau\right] - J(\mu, \tau),$$

subject to the martingale property. For every report realization r, and corresponding intermediate belief μ^r, there is an optimal corresponding signal distribution $\tau_B(\mu^r)$ of the additional signal learned by the board.

As we show below, of specific interest for our analysis are the report realizations (and the associated beliefs) for which the board chooses *not to learn* any additional information (or, to put differently, learns an uninformative signal). To study these report realizations we use

[40] The finite belief μ^t is again a function of the realized report r. We suppress it to avoid clutter.

[41] To fix ideas, consider an example with intermediate beliefs $\mu^r = (1/3, 1/3, 1/3)$ so that the Shannon entropy is $H(\mu^r) = -(1/3 \ln 1/3 + 1/3 \ln 1/3 + 1/3 \ln 1/3) = \ln 3$. A perfectly informative additional signal eliminates all uncertainty and thereby results in Shannon entropy of zero. Thus, the board's cost of acquiring such signal is $J(\mu, \tau) = \kappa(\ln 3 - 0) = \kappa \ln 3$. Alternatively, a completely uninformative private signal does not reduce any uncertainty and so the reduction in (expected) Shannon entropy is zero and the cost incurred by the board is $J(\mu, \tau) = \kappa(\ln 3 - \ln 3) = 0$. Any imperfectly informative additional signal will be associated with a cost $J(\mu, \tau) \in (0, \kappa \ln 3)$.

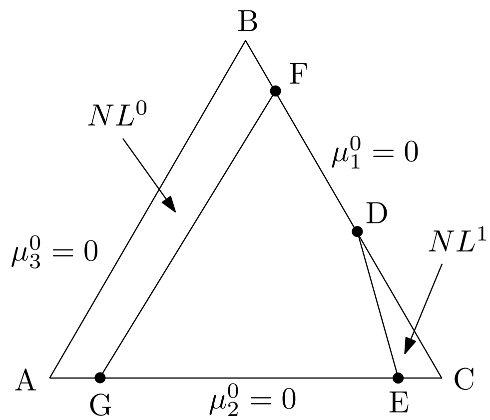


Figure 5: Interim beliefs and nonlearning regions in the simplex $\Delta(\Theta)$

a graphical argument. Because the state can assume three possible values, the board's beliefs are elements of a two-dimensional simplex $\Delta(\Theta)$. We denote its corners as $\{A, B, C\}$ with

$$\mu^A = (1,0,0); \quad \mu^B = (0,1,0); \quad \mu^C = (0,0,1).$$

Upon observing $r = A$, the board is certain that the project value is θ_1. Similarly, after $r = B$ ($r = C$) the board believes that the project value is θ_2 (θ_3). For any possible report, the board's interim belief is within the two dimensional simplex and thus is a convex combination of the corner beliefs. We label the simplex $\Delta^{ABC} \equiv \Delta(\Theta)$. In addition, let $NL^a \subset \Delta^{ABC}$ represent the set of interim beliefs for which the board chooses not to learn any additional information (and thus incurs zero learning entropy-based costs) and takes an action a. We refer to NL^a as the "nonlearning region of action a."

Lemma 11. *There exist two non-empty nonlearning regions, $NL^1 \subset \Delta^{ABC}$ and $NL^0 \subset \Delta^{ABC}$, such that:*

(i) If $\mu^r \in NL^1$, the board does not learn additional information and approves the project. For any properties of the report, the nonlearning region NL^1 of the board shrinks in the board's bias θ_B and expands in κ.

(ii) If $\mu^r \in NL^0$, the board does not learn additional information and rejects the project. For any properties of the report, the nonlearning region NL^0 expands in the board's bias θ_B and κ.

The non-learning region of approval, NL^1, and the nonlearning region of project rejection, NL^0, are graphically illustrated in Figure 5. Beliefs in the corners of the nonlearning regions, D, E, F and G, are derived in Proof to Lemma 11.

With a higher board's bias θ_B, what matters for the size of the nonlearning regions are the ratios of the board's gain from the acceptable project, $\theta_3 - \theta_B$, to the board's losses from unacceptable projects, $\theta_B - \theta_2$ and $\theta_B - \theta_1$. With a higher board's bias θ_B, the ratios decrease, which implies that NL^1 shrinks and NL^0 expands. The comparative statics with respect to κ is straightforward: The costlier it is to learn additional information, the more often the board will choose to forego learning (i.e., both regions expand).

CEO's optimal report. At date 2, the CEO chooses the properties of the report. Her problem is to find a distribution ϕ that maximizes her expected payoff subject to the martingale property. Kamenica and Gentzkow (2011) show that the optimal distribution can be obtained by concavification of the CEO's expected payoff function conditional on the observed report, i.e., the CEO's payoff function over the interim beliefs invoked by the report. Characterizing the CEO's payoff function in our setting, in the presence of the board's learning option, is nontrivial. Nevertheless, the solution of the problem can be presented elegantly. Similar to recent literature on generalized Bayesian persuasion of a rationally inattentive receiver (Matysková and Montes 2023; Caplin, Dean, and Leahy 2019), we find that the CEO optimally (i) ensures the interim beliefs are such that the board does not learn additional information and (ii) chooses the distribution of interim beliefs that maximizes the probability of the board's approval of intermediate and high-value projects. To understand why the CEO optimally avoids learning by the board, note that, while at date 2 the CEO is uncertain which report will be realized, she controls the set of possible supported realizations and the probability with which each one of these realizations is generated. Because the CEO is unconstrained in her choice and because the board's information cost is additively separable in posteriors, any information that the board decides to acquire can also be directly provided by the CEO such that the board doesn't acquire any other information. Then, the CEO controls the set of final posterior beliefs used as a basis for the board's approval decision, as well as the ex-ante distribution of these beliefs.[42]

Because the CEO optimally wants to ensure the board has no incentives to learn additional information, the candidate report realizations are in the nonlearning regions NL^0 and NL^1. Our problem can be further simplified by focusing only on the extreme points of these nonlearning regions (Matysková and Montes 2023). An extreme point of NL^a is a point with belief $\mu \in NL^a$, which does not lie on any open line segment joining two points of NL^a. Focusing on the extreme points means considering only report realizations that imply the project is one of two types, i.e., realizations that rule out one state with certainty.[43]

In our case, the set of extreme points of NL^0 is $\{A, B, F, G\}$, and the set of extreme points of NL^1 is $\{C, D, E\}$. Thus, the set of candidate realizations that could be supported by the optimal report is

$$\widehat{\mathbb{S}} = \{A, B, C, D, E, F, G\}.$$

The properties of the report on the reduced set $\widehat{\mathbb{S}}$ are represented by a distribution

$$\phi = \{\phi^A, \phi^B, \phi^C, \phi^D, \phi^E, \phi^F, \phi^G\},$$

where, as before, $\phi^r \equiv \Pr(R = r)$, $r \in \widehat{\mathbb{S}}$. The optimal report is characterized by the optimal distribution $\widetilde{\phi}$ over the reduced set $\widehat{\mathbb{S}}$, where $\widetilde{\phi} = \left(\widetilde{\phi}^r\right)_{r\in\widehat{\mathbb{S}}} = \arg\max_{\phi\in\Delta(\widehat{\mathbb{S}})} \mathbb{E}[u_C(\cdot)]$, subject to the martingale property, $\mu^o = \sum_{r\in\widehat{\mathbb{S}}} \phi^r \mu^r$. Lemma 12 below reduces the dimensionality of

[42]Caplin, Dean, and Leahy (2019) demonstrate that the board's optimal signal mixes between final beliefs that are borders of non-learning regions. The CEO can invoke them directly by the choice of the reporting technology. In addition, however, the CEO may invoke other than border points from the nonlearning regions and exactly this difference in our setting makes it strictly optimal for the CEO to discourage board learning.

[43]Technically, because the CEO's expected payoff function is linear within non-learning regions, the concave closure cannot involve only points in the interior, and any value in the interior (implying that the project can be of any type) can be achieved through a lottery on the extreme points.

the problem by establishing that the optimal report properties do not support realizations $\{E, F, G\}$.

Lemma 12. *The optimal report is not supported by interim beliefs that lie on the points* $\{E, F, G\}$*, i.e.,* $\widetilde{\phi}^E = \widetilde{\phi}^F = \widetilde{\phi}^G = 0$.

The result in Lemma 12 implies that the optimal report can only be supported by realizations $r \in \{A, B, C, D\}$. Clearly, upon observing $r \in \{A, B, C\}$, the board is fully informed and commits no approval errors. As a consequence, the only realization supported by the optimal report that leaves the board not fully informed is $r = D$. This report implies that the project either yields high, or intermediate value. For our subsequent analysis, it is instructive to describe the point D through its likelihood ratio

$$\omega(\theta_B) \equiv \frac{\Pr(\theta = \theta_3 \mid r = D)}{\Pr(\theta = \theta_2 \mid r = D)} = \frac{\mu_3^D}{1 - \mu_3^D}.$$

The larger $\omega(\theta_B)$, the larger is the probability that the project has a high value, conditional on observing $r = D$. Because, by construction, the board approves the project at point D and the only approval error occurs at point D, we label $\omega(\theta_B)$ the "approval precision" of the board. For future reference, we additionally label the likelihood ratio at the prior beliefs, $\omega^o \equiv \mu_3^o/\mu_2^o$, the "guaranteed" level of approval precision. It is also useful to introduce $\theta_B^o \in (\theta_2, \theta_3)$ as a board type satisfying $\omega^o = \omega(\theta_B^o)$, i.e., $\theta_B^o = \omega^{-1}(\omega^o)$.[44]

Corollary 3. *The board's approval precision* $\omega(\theta_B)$ *is decreasing in the cost of learning,* κ*, and increasing in the board bias,* θ_B.

As a next step, we classify all possible parametrical cases into two types depending on the intensity of the conflict between the CEO and the board. Let Δ_{ABD} be the convex hull of $\{A, B, D\}$ and Δ_{ACD} be the convex hull of $\{A, C, D\}$. When the prior belief μ^o is in Δ_{ABD}, the project is more likely to have intermediate value. Because this project is value-destroying for the firm and its shareholders, we label this case "strong conflict." It is easy to see that strong conflict is equivalent to a situation in which the approval precision exceeds the guaranteed level of precision, $\omega(\theta_B) > \omega^o$. Because the approval precision $\omega(\theta_B)$ is continuously increasing in θ_B and the guaranteed approval precision ω^o is independent of θ_B, we can also present the strong conflict as a situation in which $\theta_B > \theta_B^o$. Similarly, when the prior belief μ^o is in Δ_{ACD}, the project is more likely to have high value. Because this project adds value to the firm, we label this case "weak conflict" of interests.[45] Following a similar argument, weak conflict is characterized by $\omega(\theta_B) < \omega^o$ or, equivalently, $\theta_B < \theta_B^o$.

We are now ready to solve for the optimal properties $\widetilde{\phi}$. Proposition 6 shows that the system depends on the severity of the conflict defined above, and is not fully informative as long as the projects could be of intermediate value, $\mu_2^o > 0$. The optimal CEO's report is illustrated in Figure 6 (a).

Proposition 6 (Optimal properties of the CEO's report)**.**

[44] To see that $\theta_B^o > \theta_2$, we use that $\omega(\theta_2) = 0$ and $\omega^o > 0$. To see that $\theta_B^o < \theta_3$, we use that $\omega(\theta_3) \to \infty > \omega^o$. Notably, because μ_3^D does not depend on the properties ϕ, the cutoff θ_B^o is also independent of ϕ.

[45] Note that $\Delta_{ABD} \cup \Delta_{ACD} = \Delta(\Theta)$.

(i) For a strong conflict between the board and the CEO ($\theta_B > \theta_B^o$), the report is characterized by the optimal distribution $\widetilde{\phi} = \phi_{ABD} \equiv \left(\mu_1^o, \mu_2^o - \frac{\mu_3^o(1-\mu_3^D)}{\mu_3^D}, 0, \frac{\mu_3^o}{\mu_3^D}, 0, 0, 0\right)$. *The board approves the project after observing $r = D$ and rejects the project otherwise.*

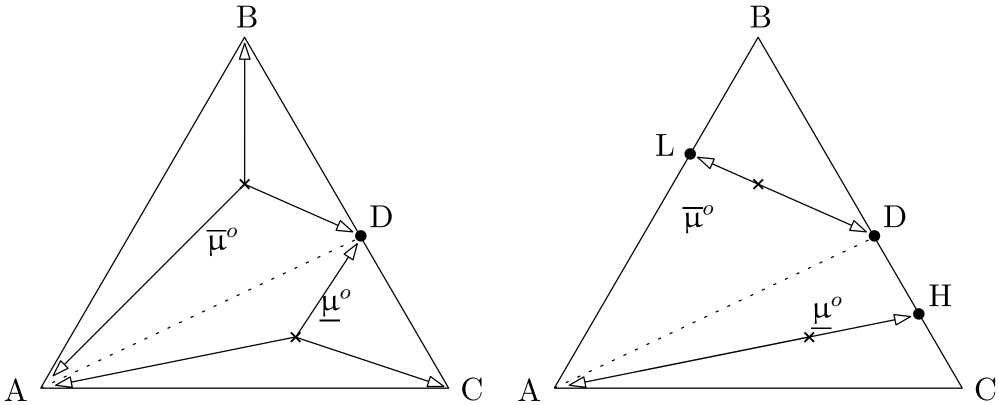
(ii) For a weak conflict between the board and the CEO ($\theta_B < \theta_B^o$), the report is characterized by the optimal distribution $\widetilde{\phi} = \phi_{ACD} \equiv \left(\mu_1^o, 0, \mu_3^o - \frac{\mu_2^o \mu_3^D}{1-\mu_3^D}, \frac{\mu_2^o}{1-\mu_3^D}, 0, 0, 0\right)$. *The board rejects the project after observing $r = A$ and approves the project otherwise.*

When the conflict between the board and the CEO is strong ($\theta_B > \theta_B^o$), only realizations $r \in \{A, B, D\}$ are supported. The project with the lowest (highest) value is always reported as $r = A$ ($r = D$). However, the intermediate type project is sometimes reported as $r = B$ and sometimes as $r = D$. Because, by construction, only $r = D$ is associated with project approval, the high-value and (with some probability) the intermediate-value projects are approved. When the conflict is weak ($\theta_B < \theta_B^o$), the optimal report only supports $r \in \{A, C, D\}$. The project with the lowest (intermediate) value is always reported as $r = A$ ($r = D$). The high-value project is sometimes reported as $r = C$ and sometimes as $r = D$. Now the board approves the project following two reports, $r \in \{C, D\}$, and the high and intermediate-value projects are approved. The reason is that, when the conflict is weak, the prior beliefs about the project value are high, and so persuading the board to approve all intermediate-value projects by mixing them with some high-value projects is feasible.

In summary, a mild conflict of interest between the CEO and the board is associated with low θ_B. In this case, the board approves the intermediate and high-value projects. Once the level of board bias reaches the critical cutoff θ_B^o, the board begins to reject some of the intermediate-value projects. Any increase in θ_B beyond that point further decreases the chance that the intermediate-value project is approved.

Corollary 4 (Probability of approval)**.** *When the conflict is weak ($\theta_B < \theta_B^o$), the ex ante probability of project approval is* $\Pr(a = 1) = \Pr(r = D) + \Pr(r = C) = \mu_2^o + \mu_3^o$. *The shareholders' ex ante expected payoff is* $\mu_3^o(\theta_3 + \theta_2/\omega^o)$. *When the conflict is strong ($\theta_B > \theta_B^o$), the ex-ante probability of project approval is given by* $\Pr(a = 1) = \Pr(r = D) = \mu_3^o/\mu_3^D \in (\mu_3^o, \mu_2^o + \mu_3^o)$ *and it is decreasing in θ_B. The shareholders' ex ante expected payoff is given by* $\mu_3^o(\theta_3 + \theta_2/\omega(\theta_B))$ *and it is increasing in θ_B.*

Benefit of board's conservatism. Regardless of the severity of the conflict, the optimal report properties do not distort the approval decision for the projects about which the CEO, the board and the shareholders agree. The lowest-value projects are always rejected, and the highest-value projects are always approved. The only distortion to the company-value-maximizing decision is that, some (or all) intermediate projects are also approved. This distortion tends to vanish when the board becomes more conservative and its conflict of interest with the CEO becomes more severe (by Lemma 11, a higher θ_B shifts the point D closer the point C), as the board is less likely to approve the intermediate-value project (see also the comparative statics in Corollary 3). It is, therefore, in the interest of the shareholders to *increase the board bias* such that the conflict between the board and the CEO is as strong as possible but also preserve $\theta_B < \theta_3$ to keep the board's preference on the highest-value project non-distorted. Formally, by Corollary 4, the shareholders' ex ante expected payoff is $\mu_3^o(\theta_3 + \theta_2/\max\{\omega^o, \omega(\theta_B)\})$, and it is maximized when θ_B approaches $\theta_3 > 0$.



(a) 3D reports (b) 2D reports

Figure 6: Equivalent characterizations of the optimal CEO's report
A weak conflict is represented by $\underline{\mu}^o$, and a strong conflict is represented by $\overline{\mu}^o$.

The optimal binary report. Because the board's action is binary (approve or reject), it is immediate that the optimal CEO's report can be simplified into one with only two realizations. This aligns with the analysis in the main part of the paper with continuous distribution where binary reports are also among the optimal reporting structures. Corollary 5 formally states this observation and Figure 6 graphically illustrates the two equivalent characterizations of the optimal system in a simplex $\Delta(\Theta)$.

Corollary 5 (2D optimal CEO's signal)**.**

(i) For a strong conflict ($\theta_B > \theta_B^o$), the optimal distribution $\widetilde{\phi}$ is equivalent to a distribution ϕ_{LD} over a subset $\{L, D\}$. The board approves the project after observing $r = D$ and rejects the project after observing $r = L$.

(ii) For a weak conflict ($\theta_B < \theta_B^o$), the optimal distribution $\widetilde{\phi}$ is equivalent to a distribution ϕ_{AH} over a subset $\{A, H\}$. The board approves the project after observing $r = H$ and rejects the project after observing $r = A$.

For a strong conflict, we coarsen the optimal 3D-report realizations with interim beliefs μ^A and μ^B at points A and B leading to rejection into a single realization with an interim belief μ^L at point L on the line AB. Report $r = L$ implies that the project has either low or intermediate value with non-zero probability. For a weak conflict, we coarsen the optimal 3D-report realizations with interim beliefs μ^C and μ^D at points C and D leading to approval into a single realization with an interim belief μ^H at point H on the line CD. Report $r = H$ implies that the project has either intermediate or high value with non-zero probability. Notice that $\mu^L \in NL^0$ and $\mu^H \in NL^1$; hence, following the coarse report L or H, the board indeed does not learn and selects the action outright.

B Proofs

Proof of Lemma 1: The solution concept is backward induction. On date 4, the board approves ($a = 1$) routine projects if $\mathbb{E}[\theta|s] \geq \rho^{routine}$ and novel projects if $\mathbb{E}[\theta|r, \theta_R] \geq \rho^{novel}$. Since s is perfectly informative, we can restate the former condition as $\theta \geq \rho^{routine}$. To streamline the analysis, we can focus on $r = h$ and restate the latter condition as $\theta \geq H(\rho^{novel})$, where $H(\cdot)$ is the inverse function of $\mathbb{E}[\theta|r = h, \theta_R]$.[46] On date 3, exercising her veto power, the CEO presents ($d = 1$) only routine projects with value $\theta \geq \max\{\rho^{routine}, \theta_C\}$.[47] For innovations, if $\theta_C \geq H(\rho^{novel})$, the CEO can set (on date 2) $\theta_R = \theta_C$ and present (on date 3) if $r = h$. Then, because in this case $\theta_R = \theta_C \geq H(\rho^{novel})$, the expected value of the presented project (at least weakly) exceeds the hurdle rate. This secures subsequent project approval of *all* favored by the CEO projects (those with value $\theta \geq \theta_C$). However, if $\theta_C < H(\rho^{novel})$, setting $\theta_R = \theta_C$ would lead to subsequent project rejection as its expected value is below the hurdle. To secure approval of projects with $r = h$, the CEO must increase θ_R.[48] The question is: by how much? It turns out that it is optimal to increase θ_R only up to the point where the expected project value conditional on high report equals the hurdle rate, $\mathbb{E}[\theta|r = h, \theta_R] = H^{-1}(\theta_R) = \rho^{novel}$, or equivalently, $\theta_R = H(\rho^{novel}) > \theta_C$. Any increase beyond that point sacrifices favored by the CEO projects that the board is willing to approve. The remainder of the proof follows from the discussion in the main text and is omitted.

Proof of Lemma 2: Follows from the discussion in the main text and is omitted.

Proof of Lemma 3: To begin, let $f_r(\theta)$ be the probability density function after $r \in \{l, h\}$ is observed. This probability is obtained by truncation of the prior distribution F at the reporting cutoff θ_R, because after $r = h$ the board realizes that the project value is in $[\theta_R, \theta_{max}]$, and after $r = l$ the board realizes that the project value is in $[\theta_{min}, \theta_R)$:

$$f_h(\theta) = \begin{cases} 0, & \text{if } \theta \in [\theta_{min}, \theta_R), \\ \frac{f(\theta)}{1-F(\theta_R)}, & \text{if } \theta \in [\theta_R, \theta_{max}]. \end{cases}$$

$$f_l(\theta) = \begin{cases} \frac{f(\theta)}{F(\theta_R)}, & \text{if } \theta \in [\theta_{min}, \theta_R) \\ 0, & \text{if } \theta \in [\theta_R, \theta_{max}]; \end{cases}$$

Now note that the interim (expected at date 4, i.e., after observing a report r with cutoff θ_R) project value is as follows:

$$\mathbb{E}[\theta|r, \theta_R] = \int_{\theta_{min}}^{\theta_{max}} \theta f_r(\theta) d\theta.$$

The board's interim (expected at date 4) payoff from approval is then,

$$\mathbb{E}[v_B(a = 1, \theta)|r, \theta_R] = \int_{\theta_{min}}^{\theta_{max}} \theta f_r(\theta) d\theta - \theta_B. \tag{3}$$

[46] The focus on $r = h$ is without loss of generality because the CEO can set θ_R arbitrarily low, as long as the board is willing to approve.

[47] If $\theta < \rho^{routine}$, the CEO is indifferent because the board will reject such a project. By our indifference assumption, she chooses $d = 0$.

[48] The expected project value under high report, $\mathbb{E}[\theta|r = h, \theta_R] = \mathbb{E}[\theta|\theta \geq \theta_R]$, is increasing in θ_R.

When deciding whether to approve the project, the board compares the interim payoff from approval in (3) with the zero-payoff from project rejection. Thus, the approval decision of the board is report-specific and is given by

$$a_r = \mathbb{1}_{\int_{\theta_{min}}^{\theta_{max}} \theta f_r(\theta)d\theta - \theta_B \geq 0}, \; r \in \{l, h\}$$

where the indicator function equals 1 if the board's interim payoff from approval is at least zero and equals zero otherwise. Because the board's interim payoff from approval is increasing in θ_R and decreasing in θ_B (for any report r), a board facing a higher (given) reporting cutoff θ_R (i.e., a higher expected project value conditional on the report) and/or a board with lower bias θ_B is more likely to approve the project proposed by the CEO.

For given θ_R, the range of the interim project value when $r = l$ is $[\theta_{min}, \mathbb{E}[\theta]]$ (see $\mathbb{E}[\theta|r = l, \theta_R] \leq \mathbb{E}[\theta]$), whereas the range of the interim project value when $r = h$ is $[\mathbb{E}[\theta], \theta_{max}]$ (see $\mathbb{E}[\theta|r = h, \theta_R] \geq \mathbb{E}[\theta]$). The two intervals overlap only in the expected value of the project, $\mathbb{E}[\theta]$. This implies that $\theta_B \lesseqgtr \mathbb{E}[\theta]$ determines the range of the indicator functions.

Exploiting this observation, we characterize the board's indifference over the project approval in the two-dimensional space of cutoffs, $(\theta_B, \theta_R) \in [\theta_{min}, \theta_{max}]^2$. First, consider the low report realization. The function $L : [\theta_{min}, \mathbb{E}[\theta]] \to [\theta_{min}, \theta_{max}]$ that yields cutoff θ_R such that the board is indifferent between project approval and rejection for a low report, is implicitly characterized by $\int_{\theta_{min}}^{\theta_{max}} \theta f_l(\theta)d\theta = \theta_B$ such that $\theta_R = L(\theta_B)$. Equivalently, $L^{-1}(\theta_R) = \int_{\theta_{min}}^{\theta_{max}} \theta f_l(\theta)d\theta$. Similarly, consider the high report realization case and specify a function $H : [\mathbb{E}[\theta], \theta_{max}] \to [\theta_{min}, \theta_{max}]$ that yields a cutoff θ_R such that the board is indifferent between project approval and rejection for a high report. The function is implicitly characterized by $\int_{\theta_{min}}^{\theta_{max}} \theta f_h(\theta)d\theta = \theta_B$ such that $\theta_R = H(\theta_B)$. Equivalently, $H^{-1}(\theta_R) = \int_{\theta_{min}}^{\theta_{max}} \theta f_r(\theta)d\theta$.

To characterize a_r, we exploit that the board's interim payoff from approval is increasing in θ_R. For $\theta_B \leq \mathbb{E}[\theta]$, consider a low report realization. The board is indifferent at $\theta_R = L(\theta_B) \in [\theta_{min}, \theta_{max}]$. We have $a_l = 0$ if $\theta_R < L(\theta_B)$ and $a_l = 1$ if $\theta_R \geq L(\theta_B)$. For a high report realization, observe that $a_h = 1$ because the board's interim payoff from approval is

$$H^{-1}(\theta_R) - \theta_B \geq H^{-1}(\theta_R) - \mathbb{E}[\theta] \geq H^{-1}(\theta_{min}) - \mathbb{E}[\theta] = 0.$$

For $\theta_B > \mathbb{E}[\theta]$, consider a high report realization. The board is indifferent at $\theta_R = H(\theta_B) \in [\theta_{min}, \theta_{max}]$. We have $a_h = 0$ if $\theta_R \leq H(\theta_B)$ and $a_h = 1$ if $\theta_R \geq H(\theta_B)$. For a low report realization, observe that $a_l = 0$ because the board's interim payoff from approval is

$$L^{-1}(\theta_R) - \theta_B < L^{-1}(\theta_R) - \mathbb{E}[\theta] \leq L^{-1}(\theta_{max}) - \mathbb{E}[\theta] = 0.$$

Proof of Lemma 4: The proof follows from the discussion in the text.

Proof of Corollary 1: The properties of the CEO's optimal reporting cutoff θ_R^* are given by the properties of R function in Lemma 4. Uniqueness of θ_H follows from the fact that H function (and also its inverse H^{-1} function) is increasing. The observation that any $\theta_B \neq \theta_H$ distorts novel investments follows from the fact that a conflict between shareholders and CEO, $\theta_S > \theta_C$, implies that R function is in its increasing part, $R(\theta_H) = H(\theta_H) > \theta_C$.

Proof of Lemma 5: Three separate claims eliminate all other candidates for the optimal board type.

Claim 1. *If the optimal board induces a weak conflict over novel project, it must be neutral:* $R(\widetilde{\theta}_B^*) = \theta_C \Rightarrow \widetilde{\theta}_B^* = \theta_S$

Suppose not: $\theta_S < \widetilde{\theta}_B^*$. Then, from the shape of $R(\theta_B)$, a weak conflict is induced for any $\theta_B \in [\theta_S, \widetilde{\theta}_B^*]$. (By Definition 1 and Lemma 4, the weak conflict exists for relevant board types, $\theta_B \in [\theta_S, \theta_H]$, on an interval $\theta_B \in [\theta_S, H^{-1}(\theta_C)]$.) On this interval, however, $W^{routine}$ is decreasing in θ_B whereas W^{novel} is constant in θ_B, and therefore the maximizer is the minimal board type θ_S, which contradicts $\theta_S < \widetilde{\theta}_B^*$.

Claim 2. *If the optimal board induces a strong conflict over novel project, it cannot be a severely biased board:* $R(\widetilde{\theta}_B^*) > \theta_C \Rightarrow \widetilde{\theta}_B^* < \theta_H$

To begin, note that a severely biased board induces a strong conflict always, $R(\theta_H) = \theta_S > \theta_C$; by continuity of $R(\theta_B)$ and $\theta_S - \theta_C > 0$, it is inducing a strong conflict also on a left neighborhood of θ_H. We will now analyze $W(\theta_B)$ on this neighborhood. We know that the marginal benefit for novel projects decreases to zero when $\widetilde{\theta}_B^*$ approaches θ_H, $\lim_{\theta_B \to \theta_H^-} \frac{dW^{novel}(\theta_B)}{d\theta_B} = 0$. At the same time, the marginal cost for routine projects is negative, $\lim_{\theta_B \to \theta_H^-} \frac{dW^{routine}(\theta_B)}{d\theta_B} = -\theta_H g(\theta_H) < 0$. To combine, the shareholders' welfare is decreasing when all value-destroying novel projects are eliminated, $\lim_{\theta_B \to \theta_H^-} \frac{dW(\theta_B)}{d\theta_B} = -p\theta_H g(\theta_H) < 0$, and therefore the optimal board is $\widetilde{\theta}_B^* < \theta_H$.

Claim 3. *If the optimal board induces a strong conflict over novel project, it cannot be neutral:* $R(\widetilde{\theta}_B^*) > \theta_C \Rightarrow \widetilde{\theta}_B^* > \theta_S$

Suppose not: $\widetilde{\theta}_B^* = \theta_S$ and $R(\theta_S) > \theta_C$. Then, by the shape of $R(\theta_B)$, a strong conflict is induced for any relevant board type, $\theta_B \in [\theta_S, \theta_H]$. At $\theta_B = \theta_S$, the marginal cost for routine projects is zero, $\left.\frac{dW^{routine}(\theta_B)}{d\theta_B}\right|_{\theta_B=\theta_S} = -\theta_S g(\theta_S) = 0$. In contrast, the marginal benefit for novel projects is positive for the strong conflict (where $R(\theta_S) = H(\theta_S) > \theta_C$ when the conflict is strong), $\left.\frac{dW^{novel}(\theta_B)}{d\theta_B}\right|_{\theta_B=\theta_S} = 1 - F(H(\theta_S)) > 0$. By combining the two effects, the ex-ante shareholders' payoff is increasing at $\theta_B = \theta_S$, $\left.\frac{dW(\theta_B)}{d\theta_B}\right|_{\theta_B=\theta_S} = (1-p)[1 - F(H(\theta_S))] > 0$. As a result, the optimal board has $\widetilde{\theta}_B^* > \theta_S$, which is a contradiction.

Proof of Proposition 1: For each condition, we construct a separate claim.

Claim 4. *If* $\widetilde{\theta}_B^* = \theta_S$ *then* $R(\theta_S) = \theta_C$.

Suppose not: $\widetilde{\theta}_B^* = \theta_S$ and $R(\theta_S) > \theta_C$. Then, by Claim 3 from Proof of Lemma 5, $\widetilde{\theta}_B^* > \theta_S$, which is a contradiction.

Claim 5. *If* $\widetilde{\theta}_B^* > \theta_S$ *then it holds that* $(1-p)[W^{novel}(\theta_H) - W^{novel}(\theta_S)] \geq p[W^{routine}(\theta_S) - W^{routine}(\max\{\theta_S, H^{-1}(\theta_C)\})]$

Recall the left-hand side of the inequality (LHS) is the maximal benefit of a strong conflict (novel projects side) and the right-hand side of the inequality (RHS) is the minimal cost of a strong conflict (routine projects side). We prove by contradiction: Suppose the optimal board is biased but the maximal benefit is below the minimal cost (LHS below RHS). Three cases exist:

- $H^{-1}(\theta_C) \leq \theta_S$. Then, a strong conflict is induced for any relevant board type $\theta_B \geq \theta_S$. The minimal cost is zero but the maximal benefit is positive, $W^{novel}(\theta_H) - W^{novel}(\theta_S) > 0$. This contradicts that the maximal benefit is below the minimal cost.

- $H^{-1}(\theta_C) > \theta_S$ and $\widetilde{\theta}_B^* \in [\theta_S, H^{-1}(\theta_C)]$ (weak conflict induced). By Claim 1 in Proof of Lemma 5, the optimal board is neutral if the conflict is weak; this is a contradiction.

- $H^{-1}(\theta_C) > \theta_S$ and $\widetilde{\theta}_B^* \in [H^{-1}(\theta_C), \theta_H]$ (strong conflict induced). On this interval, the shareholders' payoff is bounded by $\overline{W}$ from above,

$$\begin{aligned} W(\theta_B) &= p\, W^{routine}(\theta_B) + (1-p)\, W^{novel}(\theta_B) \\ &< p\, W^{routine}(H^{-1}(\theta_C)) + (1-p)\, W^{novel}(\theta_H) \equiv \overline{W}, \end{aligned}$$

  because on this interval, $W^{routine}$ is maximized at $\theta_B = H^{-1}(\theta_C)$ and W^{novel} is maximized at θ_H. Now, we use that the condition that the maximal benefit exceeds the minimal cost can be rearranged into $W(\theta_S) \leq \overline{W}$. Therefore, since we suppose the maximal benefit is below the minimal cost, we have $W(\theta_S) > \overline{W}$. This contradicts that $\overline{W}$ is an upper bound of $W(\theta_B)$.

Proof of Corollary 2: Like in Proof of Proposition 1, LHS denotes the left-hand side of the inequality in condition (ii) (the maximal benefit of a strong conflict) and RHS denotes the right-hand side of the inequality (the minimal cost of a strong conflict). The proof follows from the following three observations:

- LHS is decreasing in p whereas RHS is increasing in p; therefore, a unique cutoff $p^* \in [0, 1]$ exists.

- At the limit, as $p \to 0$, LHS becomes $W^{novel}(\theta_H) - W^{novel}(\theta_S) > 0$ whereas RHS becomes 0 so that the condition is satisfied. Therefore, the cutoff is positive, $p^* > 0$.

- At the limit, as $p \to 1$, LHS becomes 0 whereas RHS becomes

$$W^{routine}(\theta_S) - W^{routine}(\max\{\theta_S, H^{-1}(\theta_C)\}) \geq 0.$$

  If $\theta_S < H^{-1}(\theta_C)$, RHS is positive, the condition is violated and the cutoff is $p^* < 1$. Otherwise, both LHS and RHS are zero, the condition is satisfied, and $p^* = 1$.

Proof of Lemma 6: The board updates its prior belief F into a posterior belief F^r, where $F^r(\theta) = \frac{F(\theta) - F(\underline{\theta})}{F(\overline{\theta}) - F(\underline{\theta})}$ for $\theta \in [\underline{\theta}, \overline{\theta}]$.

Part (i): Suppose the board's preferred decision after r is acceptance, $a_r = 1$. If $\underline{\theta} \geq \theta_B$, the board would approve any project under full information. Thus, the board's value of information is zero and, consequently, the board does not learn, i.e., sets $\theta_M = \underline{\theta}$. If $\underline{\theta} < \theta_B$, the board wants to revise the acceptance decision for low-value projects by setting a cutoff $\theta_M \in (\underline{\theta}, \theta_B]$. With this cutoff, the information acquisition cost is $C(\theta_M, \kappa) = \kappa F^r(\theta_M)$. By increasing θ_M, the marginal board's information acquisition cost is $\frac{dC(\theta_M,\kappa)}{d\theta_M} = \kappa f^r(\theta_M)$, and the marginal board's benefit from a higher θ_M is $(\theta_B - \theta_M)f^r(\theta_M)$. The interior optimum is at $\theta_B - \kappa < \theta_B$; to account for the lower corner, $\theta_M \geq \underline{\theta}$, the optimum is $\theta_M = \max\{\theta_B - \kappa, \underline{\theta}\}$.

Part (ii): Suppose the board's preferred decision after r is rejection, $a_r = 0$. If $\overline{\theta} \leq \theta_B$, the board would reject any project under full information. Thus the board's value of information is zero and, consequently, the board does not learn, i.e., $\theta_M = \overline{\theta}$. If $\overline{\theta} > \theta_B$, the board wants to revise the rejection decision for high-value projects by setting a cutoff $\theta_M \in [\theta_B, \overline{\theta})$. With this cutoff, the information acquisition cost is $C(\theta_M, \kappa) = \kappa[1 - F^r(\theta_M)]$. By decreasing θ_M, the marginal board's information acquisition cost is $\frac{dC(\theta_M,\kappa)}{d-\theta_M} = \kappa f^r(\theta_M)$, and the marginal board's benefit from a lower θ_M is $(\theta_M - \theta_B)f^r(\theta_M)$. The interior optimum is at $\theta_B + \kappa > \theta_B$; to account for the upper corner, $\theta_M \leq \underline{\theta}$, the optimum is $\theta_M = \min\{\theta_B + \kappa, \overline{\theta}\}$.

Proof of Lemma 7: For $\theta_B \leq \theta_C$, the optimal reporting cutoff is clearly $\theta_R = \theta_C$ as the board then approves the project without learning. For $\theta_B > \theta_C$, we construct the board's optimal report (which is also the board's decision cutoff) as a function of θ_R: (i) For $\theta_R < H(\theta_B)$, the board's preferred decision is rejection, and $\theta_M = \min\{\theta_{max}, \theta_B + \kappa\}$. (Notice that this interval is empty when $H(\theta_B) < \theta_C$.) (ii) For $\max\{\theta_C, H(\theta_B)\} \leq \theta_R \leq \theta_B$, the board's preferred decision is acceptance, and $\theta_M = \max\{\theta_R, \theta_B - \kappa\}$. (iii) For $\theta_R > \theta_B$, the board accepts and does not learn, $\theta_M = \theta_R$.

Note that $\theta_M \geq \theta_C$ and therefore the CEO seeks to minimize θ_M. Clearly, this is in the interval (ii), where $\theta_M = \max\{\theta_R, \theta_B - \kappa\}$. Any report from the interval (i) is clearly worse for the CEO than the report (and decision cutoff) $\theta_R = \theta_B$, because $\theta_M = \min\{\theta_{max}, \theta_B + \kappa\} > \theta_B$. Also, any report from the interval (iii) is clearly worse for the CEO than the report (and decision cutoff) $\theta_R = \theta_B$, because $\theta_M = \theta_R > \theta_B$.

The interval (ii) is characterized by the reports $\theta_R \in [\max\{\theta_C, H(\theta_B)\}, \theta_B]$, and the board's decision cutoff $\theta_M = \max\{\theta_R, \theta_B - \kappa\}$. On this interval, the value of θ_M is minimized (closest to the value θ_C) when $\theta_R \geq \max\{\theta_C, H(\theta_B)\}$ and $\theta_R \leq \theta_B - \kappa$. Using $R(\theta_B) = \max\{\theta_C, H(\theta_B)\}$ and introducing $\widehat{R}(\theta_B) = \max\{\theta_C, H(\theta_B), \theta_B - \kappa\}$, this is equivalent for $\theta_R \in [R(\theta_B), \widehat{R}(\theta_B)]$. The board's decisions at dates 3 and 4 follow from Lemma 6.

Proof of Lemma 8: Introducing a learning option affects only decisions for novel projects. Without learning option, the projects $\theta \geq R(\theta_B)$ are approved. With learning option, the projects $\theta \geq \widehat{R}(\theta_B) \geq R(\theta_B)$ are approved. The approval is less likely as projects $\theta \in [R(\theta_B), \widehat{R}(\theta_B)]$ are now rejected. There are three cases: (i) If $\theta_B \leq \widehat{\theta}_H$, we have $R(\theta_B) \leq \widehat{R}(\theta_B) \leq \theta_S$; board learning mitigates investment distortions. (ii) If $\theta_B \geq \theta_H$, we have $\theta_S \leq R(\theta_B) \leq \widehat{R}(\theta_B)$. The board's learning amplifies investment distortions. (iii) In the intermediate case, the board's learning mitigates investment distortions for $\theta \in [R(\theta_B), \theta_S)$ but introduces new distortions for $\theta \in [\theta_S, \widehat{R}(\theta_B))$.

Proof of Proposition 2: First, we analyze the effect of a higher learning cost on shareholders' welfare. The shareholders' optimal board problem is to maximize $W(\theta_B)$ subject to the constraint $\theta_R = \widehat{R}(\theta_B)$. The relevant board types are $\theta_B \in [\theta_S, \widehat{\theta}_H)]$; for these types, $\theta_R \in$

$[\theta_C, \theta_S]$. Intuitively, in the parameter space of (θ_B, θ_R), the shareholders want as low θ_B as possible (to not distort routine projects) and also as high θ_R as possible (to not distort novel projects). A higher κ reduces $\theta_B - \kappa$ function and consequently (weakly) reduces the reporting cutoff function, $\widehat{R}(\theta_B) = \max\{\theta_C, H(\theta_B), \theta_B - \kappa\}$. A higher κ thus makes the shareholders' constraint, $\theta_R = \widehat{R}(\theta_B)$ tighter, which implies that the maximized shareholders' welfare is (weakly) reduced.

Second, we analyze the effect of a higher learning cost on the type of the board (neutral or biased). A higher κ (weakly) reduces $\widehat{R}(\theta_B)$. We know that the shareholders' optimal board is chosen from two conditionally optimal boards: (i) for low θ_B such that $\widehat{R}(\theta_B) = \theta_C$ (weak conflicts), the conditionally optimal board is neutral, whereas for (ii) high θ_B such that $\widehat{R}(\theta_B) > \theta_C$ (strong conflicts), the conditionally optimal board is biased. The shareholders' welfare associated with the neutral board in a weak conflict is constant in the cost κ, since the pair $(\theta_B, \theta_R) = (\theta_S, \theta_C)$ is invariant in the cost, whereas the welfare associated with the biased board in a strong conflict is (weakly) decreasing in the cost κ as $\widehat{R}(\theta_B)$ (weakly) decreases in κ. This implies that the shareholders may switch from the biased board to the neutral board when the learning cost increases, but not vice versa.

To complete the argument, we also have to analyze the effect of a higher learning cost on the existence of a weak conflict for a neutral board which is a necessary condition for a neutral board. This effect is positive; a decrease in $\widehat{R}(\theta_B)$ implies that it is more likely that a weak conflict begins to exist for a neutral board, i.e., it is more likely that we switch from a case with $\widehat{R}(\theta_S) > \theta_C$ to a case with $\widehat{R}(\theta_S) < \theta_C$. To sum up, with a higher learning cost, it is more likely that a weak conflict begins to exist for a neutral board, and also more likely that the board switches from the biased board to the neutral board (conditional on the existence of weak conflict for the neutral board); the two effects thus jointly imply that with a higher learning cost, the board is more likely neutral.

Proof of Proposition 3: For a given project category $t \in \{novel, routine\}$, let $W^t(\theta_B)$ be the shareholders' welfare when the board is of type θ_B and the CEO is willing to select project category t. Let $\overline{W}^t$ denote the maximal welfare for each project category, i.e., $\overline{W}^{routine} = W^{routine}(\theta_S)$ and $\overline{W}^{novel} = W^{novel}(\theta_H)$.

Part (i). We first prove that if $F(\theta) \leq G(\theta)$ for any θ (F and G are identical or F first-order stochastically dominates G), then $\overline{W}^{novel} \geq \overline{W}^{routine}$. We know that the shareholders' optimal decision cutoff for each project category is at θ_S. Applying this decision cutoff (i.e., for any $\theta < \theta_S$, the probability mass is shifted to an atom at θ_S where the shareholders' welfare is zero), we obtain adjusted distributions F^{adj} and G^{adj} that account for the rejections of projects with negative value. Namely, $F^{adj}(\theta) = G^{adj}(\theta) = 0$ if $\theta < \theta_S$, and $F^{adj}(\theta) = F(\theta)$ and $G^{adj}(\theta) = G(\theta)$ if $\theta \geq \theta_S$. Since the adjusted distributions preserve the first-order stochastic dominance (as well as identity), $F^{adj}(\theta) \leq G^{adj}(\theta)$ for any θ, novel projects are on average at least as profitable as routine projects when the shareholders can implement the optimal decision cutoff θ_S for any project category, $\overline{W}^{novel} = \int_{\theta_S}^{\theta_{max}} \theta f(\theta) d\theta \geq \int_{\theta_S}^{\theta_{max}} \theta g(\theta) d\theta = \overline{W}^{routine}$.

Thus, if $F(\theta) \leq G(\theta)$ for any θ, the shareholders primarily seek to obtain value $\overline{W}^{novel}$. This value is attainable by the shareholders. Namely, when the board is extreme, $\theta_B = \theta_H$, inequalities $W^{novel}(\theta_H) = \overline{W}^{novel} \geq \overline{W}^{routine} > W^{routine}(\theta_H)$ and $G(\theta_H) - F(R(\theta_H)) \geq F(\theta_H) - F(R(\theta_H)) > 0$ jointly imply $M(\theta_H) > 0$. (See also fn. 21.) In other words, CEO's and shareholders' preferences over project selection at $\theta_B = \theta_H$ are aligned and this value is attainable.

Part (ii). By analogy to the claim above, if $F(\theta) \geq G(\theta)$ for any θ where $F(\theta) > G(\theta)$ for some θ (G first-order stochastically dominates F), then $\overline{W}^{novel} < \overline{W}^{routine}$. The shareholders seek to attain value $\overline{W}^{routine}$. If $M(\theta_S) < 0$, this value is attainable when $\theta_B = \theta_S$ because CEO's and shareholders' preferences are aligned at $\theta_B = \theta_S$.

The value $\overline{W}^{routine}$ is not feasible when $M(\theta_S) \geq 0$; the CEO's and shareholders' preferences over project selection are not aligned at $\theta_B = \theta_S$. We proceed in several steps. First, by contradiction, we prove $\theta_B^* \neq \theta_S$. Suppose not, $\theta_B^* = \theta_S$. Since $M(\theta_S) \geq 0$, it means that a combination of neutral board and novel project is optimal for the shareholders.

- When $R(\theta_S) > \theta_C$ (strong conflict with a neutral board), $R(\theta_B)$ is increasing if $\theta_B \in [\theta_S, \theta_H]$ and therefore also $W^{novel}(\theta_B)$ is increasing. For the neutral board to be constrained optimal for novel projects, we must have that $M(\theta_B) < 0$ if $\theta_B \in (\theta_S, \theta_H]$ (i.e., any increase in θ_B forces the CEO to select the routine project). But if $M(\theta_S) > 0$, this is impossible due to continuity of M function. If $M(\theta_S) = 0$, the neutral board is not constrained optimal because by continuity of $W^{routine}$ function, there exists a board $\theta_B \in (\theta_S, \theta_S + \varepsilon)$ which selects a routine project such that $W^{routine}(\theta_B) > \overline{W}^{novel} > W^{novel}(\theta_S)$.

- When $R(\theta_S) = \theta_C$ (weak conflict with a neutral board), $R(\theta_B)$ is constant if $\theta_B \in [\theta_S, H^{-1}(\theta_C)]$. Therefore, on this interval, the CEO's expected payoff from a novel project is also constant, whereas her expected payoff from a routine project is decreasing. As a result, $M(\theta_B) > M(\theta_S) \geq 0$ if $\theta_B \in (\theta_S, H^{-1}(\theta_C)]$. By continuity of M function, we must therefore have $M(\theta_B) > 0$ also for $\theta_B \in [H^{-1}(\theta_C), H^{-1}(\theta_C) + \varepsilon)$ where $R(\theta_B)$ is increasing. But if $R(\theta_B)$ is increasing, also $W^{novel}(\theta_B)$ is increasing, and the shareholders will strictly prefer decisions on the novel project with a biased board $\theta_B \in (H^{-1}(\theta_C), H^{-1}(\theta_C) + \varepsilon)$ to decisions on the novel project with a neutral board $\theta_B = \theta_S$. This is a contradiction.

Second, we prove $\theta_B^* > \theta_C$ by ruling out $\theta_B^* = \theta_C$ and $\theta_B^* < \theta_C$. We start by observing that a board aligned with the CEO, $\theta_B = \theta_C$, convinces the CEO to select a routine project. This is because $R(\theta_C) = \theta_C$, and therefore by first-order stochastic dominance, $M(\theta_C) = W^{novel}(\theta_C) - W^{routine}(\theta_C) < 0$. At the same time, recall $M(\theta_S) \geq 0$. By continuity of M function, $M(\theta_B) < 0$ also on the neighborhood $\theta_B \in (\theta_C, \theta_C + \varepsilon)$ for some small $\varepsilon > 0$. But shareholders welfare, $W^{routine}(\theta_B)$, is increasing on the neighborhood and thus $\theta_B^* \neq \theta_C$.

Next, suppose $\theta_B^* < \theta_C$. If the CEO selects a routine, the outcome with θ_B^* is equivalent to the one with $\theta_B = \theta_C$ because the decision cutoff for routine projects is at $\max\{\theta_B^*, \theta_C\} = \theta_C$. If the CEO selects a novel project, θ_B^* is suboptimal for the shareholders because a higher welfare is achieved for $\theta_B = \theta_S$ where the CEO also selects a novel project.

Proof of Proposition 4: We proceed in two steps. In the first step, we take reporting strategy $\theta_R = R(\theta_B)$ and presentation strategy $(d_l, d_h) = (0, 1)$ as given and prove that only a babbling cheap talk equilibrium exists. In the second step, we prove that the CEO does not deviate from the reporting and presentation strategies, $R(\theta_B)$ and $(d_l, d_h) = (0, 1)$.

Step 1: We analyze only report-specific cheap talk for $r = h$, because the project is not presented for $r = l$. Conditional on high report, $\theta \in M_h \equiv [\theta_R, \theta_{max}]$. There exists a babbling equilibrium where the CEO sends a single message that θ belongs to M_h: in this case the project is approved. It is easy to see that there does not exist a two-message equilibrium. In such equilibrium the interval M_h is partitioned into (M_h^-, M_h^+). Because the board approves the project when the message is that $\theta \in M_h$, it also approves the project when the message is that $\theta \in M_h^+$. However, if the CEO observes $\theta \in M_h^-$, she communicates that $\theta \in M_h^+$ because she wants the project to be approved (see $\theta \geq \theta_R = R(\theta_B) \geq \theta_C$). Thus the communication degenerates into babbling.

Step 2: In the previous step we showed that, when the reporting cutoff is $\theta_R = R(\theta_B)$, the cheap talk is uninformative and the board's information is characterized by a partition at θ_R. Is there any other partition that is better for the CEO from an ex-ante perspective? By Lemma 4, the partition at the cutoff $R(\theta_B)$ is the best for the CEO partition under which the board is willing to approve the project after message $r = h$. A finer partitioning cannot increase the CEO's expected payoff. To do so, such partition must result in project approval for some $\theta \in (\theta_C, R(\theta_B))$, which is impossible since $\theta = R(\theta_B)$ is the lowest value of project that the board approves in any partition.

Proof of Proposition 5: Consider the case where the constraint for upper bound is loose, $L(\theta_C + \gamma) \geq \theta_S$. Then, a board with $\theta_B = \theta_H$ implements the shareholders' first best outcome. Now suppose that this constraint is binding, $L(\theta_C + \gamma) < \theta_S$. If the board is characterized with $\theta_B = \theta_H$, only an uninformative pooling equilibrium where the project is rejected can arise. The shareholders compare two outcomes: (i) set $\theta_B = H^{-1}(L(\theta_C + \gamma)) \in (\theta_S, \theta_H)$ and incentivize informative communication with the lowest possible overinvestment or (ii) set any $\theta_B \in (H^{-1}(L(\theta_C + \gamma)), \theta_{max}]$ and acquiesce to project rejection after uninformative communication. By our tie-breaking assumption, $\theta_B = \theta_{max}$ in this case. The former cutoff means overinvestment and the latter cutoff means underinvestment (in fact, zero investment), because $H^{-1}(L(\theta_C + \gamma)) < \theta_H < \theta_{max}$ and any board with $\theta_B < \theta_H$ overinvests while any board with $\theta_B > \theta_H$ underinvests in novel projects.

When $\theta_S \leq \mathbb{E}[\theta]$, the shareholders prefer option (i) because project approval after $r = h$ generates a positive value, $\mathbb{E}[\theta|\theta \geq \theta_R] > \mathbb{E}[\theta] \geq \theta_S$. When $\theta_S \geq \mathbb{E}[\theta]$, the shareholders prefer option (i) only when $L(\theta_C + \gamma) > H(\theta_S)$. (Note that the shareholders of type $\theta_S > \mathbb{E}[\theta]$ earn a non-negative project value if $\theta_R \geq H(\theta_S)$.) In contrast, when $H(\theta_S) > L(\theta_C + \gamma)$, the shareholders prefer option (ii).

Proof of Lemma 9: By Lemma 7, for given κ, the CEO optimally sets $\theta_R \in [R(\theta_B), \widehat{R}(\theta_B, \kappa)]$ and expects the decision cutoff $\theta_M = \widehat{R}(\theta_B, \kappa)$. Take the union of the intervals $[R(\theta_B), \widehat{R}(\theta_B, \kappa)]$ for all feasible levels of κ, i.e., the interval $[R(\theta_B), \widehat{R}(\theta_B, \overline{\kappa})]$. For any θ_R from this interval, the board's decision cutoff is, conditionally on κ, $\theta_M = \widehat{R}(\theta_B, \kappa)$. This is an identical decision cutoff that the CEO would implement if she knew κ in advance. Therefore, it is optimal for the CEO to set $\theta_R \in [R(\theta_B), \widehat{R}(\theta_B, \overline{\kappa})]$; this achieves an equivalent outcome as if the CEO observes the realization of an unknown κ.

Proof of Lemma 10: For given κ, we know that the optimal board is $\widehat{\theta}_H = \min\{\theta_H, \theta_S + \kappa\}$, which is increasing in κ. For an uncertain κ, the optimal board must be in-between the least conservative optimal board (i.e., the optimal board for the lowest learning cost) and the most conservative optimal board (i.e., the optimal board for the highest learning cost), $\min\{\theta_H, \theta_S + \underline{\kappa}\} \le \widehat{\theta}_H \le \min\{\theta_H, \theta_S + \overline{\kappa}\}$. Since $\underline{\kappa} > 0$, the optimal board is biased, $\widehat{\theta}_H > \theta_S$.

Proof of Lemma 11: When characterizing the extreme points of NL^0 and NL^1, we apply Proposition 2 in Caplin, Dean, and Leahy (2019). It characterizes the optimal strategy of a rationally inattentive receiver (i.e., board) that satisfies the martingale property. In particular, we use the fact that, if the project decision is binary (approve or reject) and an interim belief is located in a learning region, the optimal board information acquisition strategy is a lottery over two final beliefs. The first final belief, μ^t, is in the border of NL^1 (a point t) and leads to the project approval, and the second final belief $\mu^{t'}$ is in the border of NL^0 (a point t') and leads to the project rejection. To derive these borderline posterior beliefs, we apply the 'Invariant Likelihood Ratio (ILR) Equations for Chosen Options' property. Its geometric interpretation in 2D-space is that the slopes of the board's net payoff function at points t and t', $\sum_j \mu_j^t u_B(1,\theta_j) + \kappa H(\mu^t)$ and $\sum_j \mu_j^t u_B(0,\theta_j) + \kappa H(\mu^{t'})$, must be identical. Intuitively, this property uses the fact that the board's net payoff function emerges as a result of concavification and, after concavification, the payoff function is by definition linear in the learning region and strictly concave in non-learning regions. Figure 5 in Caplin, Dean, and Leahy (2019) illustrates this property.

We begin with deriving the extreme points D and F on the BC-line where $\mu_1 = 0$ and $\mu_2 + \mu_3 = 1$. In the borderline point D, the board approves the project, and the board's net payoff function is $\mu_3^D(\theta_3 - \theta_B - \kappa \ln \mu_3^D) + (1-\mu_3^D)(\theta_2 - \theta_B - \kappa \ln(1-\mu_3^D))$; its slope in μ_3-dimension is $(\theta_3 - \theta_B - \kappa \ln \mu_3^D) - (\theta_2 - \theta_B - \kappa \ln(1-\mu_3^D))$. In the borderline point F, the board rejects the project, and the board's net payoff function is $-\mu_3^F \kappa \ln \mu_3^F - (1-\mu_3^F)\kappa \ln(1-\mu_3^F))$. Its slope in μ_3-dimension is $-\kappa \ln \mu_3^F + \kappa \ln(1-\mu_3^F)$. Like in Caplin, Dean, and Leahy (2019), we use that the slopes are equal if the state-specific components are equal across states, $\theta_3 - \theta_B - \kappa \ln \mu_3^D = -\kappa \ln \mu_3^F$ and $\theta_2 - \theta_B - \kappa \ln(1-\mu_3^D) = -\kappa \ln(1-\mu_3^F)$. After rearranging, $e^{\frac{1}{\kappa}(\theta_3-\theta_B)} = \frac{\mu_3^D}{\mu_3^F}$ and $e^{\frac{1}{\kappa}(\theta_2-\theta_B)} = \frac{1-\mu_3^D}{1-\mu_3^F}$. The unique solution to this system of two linear equations is

$$(\mu_3^D, \mu_3^F) = \left(\frac{e^{\frac{1}{\kappa}(\theta_3-\theta_2)} - e^{\frac{1}{\kappa}(\theta_3-\theta_B)}}{e^{\frac{1}{\kappa}(\theta_3-\theta_2)} - 1}, \frac{e^{\frac{1}{\kappa}(\theta_B-\theta_2)} - 1}{e^{\frac{1}{\kappa}(\theta_3-\theta_2)} - 1} \right).$$

Note that for $\theta_B \in (\theta_2, \theta_3)$, it always holds that $\mu_3^D \in (0,1)$ and $\mu_3^F \in (0,1)$. That is, NL^1 is non-empty.

The extreme points E and G are on the AC-line where $\mu_2 = 0$ and $\mu_1 + \mu_3 = 1$. In the borderline point E, the board approves the project, and the board's net payoff function is $\mu_3^E(\theta_3 - \theta_B - \kappa \ln \mu_3^E) + (1-\mu_3^E)(\theta_1 - \theta_B - \kappa \ln(1-\mu_3^E))$. Its slope in μ_3-dimension is $(\theta_3 - \theta_B - \kappa \ln \mu_3^E) - (\theta_1 - \theta_B - \kappa \ln(1-\mu_3^E))$. In the borderline point G, the board rejects the project, and the board's net payoff function is $-\mu_3^G \kappa \ln \mu_3^G - (1-\mu_3^G)\kappa \ln(1-\mu_3^G))$. Its slope in μ_3-dimension is $-\kappa \ln \mu_3^G + \kappa \ln(1-\mu_3^G)$. Imposing that the state-specific components are equal across states and rearranging yields $e^{\frac{1}{\kappa}(\theta_3-\theta_B)} = \frac{\mu_3^E}{\mu_3^G}$ and $e^{\frac{1}{\kappa}(\theta_1-\theta_B)} = \frac{1-\mu_3^E}{1-\mu_3^G}$. The unique solution to this system of two linear equations is

$$(\mu_3^E, \mu_3^G) = \left(\frac{e^{\frac{1}{\kappa}(\theta_3-\theta_1)} - e^{\frac{1}{\kappa}(\theta_3-\theta_B)}}{e^{\frac{1}{\kappa}(\theta_3-\theta_1)} - 1}, \frac{e^{\frac{1}{\kappa}(\theta_B-\theta_1)} - 1}{e^{\frac{1}{\kappa}(\theta_3-\theta_1)} - 1} \right).$$

Note that for $\theta_B \in (\theta_2, \theta_3)$, it always holds that $\mu_3^E \in (0,1)$ and $\mu_3^G \in (0,1)$. That is, NL^0 is non-empty. □

Proof of Lemma 12: The proof is by contradiction. Let $W(\mu) \equiv \mathbb{E}[u_C(\cdot) \mid r]$ be the expected payoff of the CEO at the interim stage for given report realization (and the interim belief μ that it invokes). We refer to $W(\mu)$ as the CEO's "indirect value function."[49] The optimal report is characterized by the distribution $\widetilde{\phi}$ over the reduced set $\widehat{\mathbb{S}}$, where

$$\widetilde{\phi} = \left(\widetilde{\phi}^r\right)_{r\in\widehat{\mathbb{S}}} = \arg \max_{\phi\in\Delta(\widehat{\mathbb{S}})} \sum_{r\in\widehat{\mathbb{S}}} \phi^r W(\mu^r), \tag{4}$$

subject to the martingale property, $\mu^o = \sum_{r\in\widehat{\mathbb{S}}} \phi^r \mu^r$.[50] We show that any distribution with a positive ϕ^E, ϕ^F, or ϕ^G is not optimal.

(i) Suppose $\widetilde{\phi}^E > 0$: Construct a refined distribution $\widehat{\phi}$ by redistributing all probability mass from point E to points A and C. The probability mass is divided into $(1-\mu_3^E, \mu_3^E) = (\mu_1^E, \mu_3^E)$ shares such that the martingale property is satisfied, $(1-\mu_3^E)\mu^A + \mu_3^E\mu^C = \mu^E$. That is, $\widehat{\phi}_A = \widetilde{\phi}^A + \mu_1^E\widetilde{\phi}^E < 1$, $\widehat{\phi}_C = \widetilde{\phi}^C + \mu_3^E\widetilde{\phi}^E < 1$, $\widehat{\phi}_E = 0$, and $\widehat{\phi} = \widetilde{\phi}$ otherwise. The redistribution increases the CEO's objective,

$$\sum_{r\in\widehat{\mathbb{S}}} \widehat{\phi} W(\mu) - \sum_{r\in\widehat{\mathbb{S}}} \widetilde{\phi} W(\mu) = \widetilde{\phi}^E[\mu_1^E W(\mu^A) + \mu_3^E W(\mu^C) - W(\mu^E)] = -\widetilde{\phi}^E \mu_1^E W(\mu^A) > 0,$$

which follows from $\mu_1^E > 0$, $\widetilde{\phi}^E > 0$, and $W(\mu^A) = \theta_1 - \theta_C < 0$.

(ii) Suppose $\widetilde{\phi}^F > 0$: By analogy, construct a refined distribution $\widehat{\phi}$ by redistributing all probability mass from point F to points B and C. The probability mass is divided into $(1-\mu_3^F, \mu_3^F) = (\mu_2^F, \mu_3^F)$ shares such that the martingale property is satisfied, $(1 - \mu_3^F)\mu^B + \mu_3^F\mu^C = \mu^F$. That is, $\widehat{\phi}_B = \widetilde{\phi}^B + \mu_2^F\widetilde{\phi}^F < 1$, $\widehat{\phi}_C = \widetilde{\phi}^C + \mu_3^F\widetilde{\phi}^F < 1$, $\widehat{\phi}_F = 0$, and $\widehat{\phi} = \widetilde{\phi}$ otherwise. The redistribution increases the CEO's objective,

$$\sum_{r\in\widehat{\mathbb{S}}} \widehat{\phi} W(\mu) - \sum_{r\in\widehat{\mathbb{S}}} \widetilde{\phi} W(\mu) = \widetilde{\phi}^F[\mu_2^F W(\mu^B) + \mu_3^F W(\mu^C) - W(\mu^F)] = \widetilde{\phi}^F \mu_3^F W(\mu^C) > 0,$$

which follows from $\mu_3^F > 0$, $\widetilde{\phi}^F > 0$, and $W(\mu^C) = \theta_3 - \theta_C > 0$.

(iii) Suppose $\widetilde{\phi}^G > 0$: Like in the case of point E, construct a refined distribution $\widehat{\phi}$ by redistributing all probability mass from point G to points A and C. The probability mass is divided into $(1-\mu_3^G, \mu_3^G) = (\mu_1^G, \mu_3^G)$ shares such that the martingale property is

[49] Because the report discourages additional information acquisition, the board's action at the interim stage (i.e., for given belief μ) is a deterministic variable, characterized by a function, $\sigma : \Delta(\Theta) \to \{0,1\}$. With this observation, we can easily express the expected payoff of the CEO at the interim stage: $W(\mu) = \sigma(\mu)\left(\sum_j \mu_j\theta_j - \theta_C\right)$.

[50] More precisely, the problem is characterized by 18 constraints, where 14 inequalities and one equality are due to the existence of a simplex, $0 \leq \phi^r \leq 1, r \in \widehat{\mathbb{S}}$, $\sum_{r\in\widehat{\mathbb{S}}} \phi^r = 1$, and three equalities are the martingale properties: $\mu_j^o = \sum_{r\in\widehat{\mathbb{S}}} \phi^r \mu_j^r$, $j = 1, 2, 3$.

satisfied, $(1-\mu_3^G)\upmu^A+\mu_3^G\upmu^C=\upmu^G$. That is, $\widehat{\phi}_A=\widetilde{\phi}^A+\mu_1^G\widetilde{\phi}^G<1$, $\widehat{\phi}_C=\widetilde{\phi}^C+\mu_3^G\widetilde{\phi}^G<1$, $\widehat{\phi}_G=0$, and $\widehat{\upphi}=\widetilde{\upphi}$ otherwise. The redistribution increases the CEO's objective,

$$\sum_{r\in\widehat{\mathbb{S}}}\widehat{\upphi}W(\upmu)-\sum_{r\in\widehat{\mathbb{S}}}\widetilde{\upphi}W(\upmu)=\widetilde{\phi}^G[\mu_1^GW(\upmu^A)+\mu_3^GW(\upmu^C)-W(\upmu^G)]=\widetilde{\phi}^G\mu_3^GW(\upmu^C)>0,$$

which follows from $\mu_3^G>0$, $\widetilde{\phi}^G>0$, and $W(\upmu^C)=\theta_3-\theta_C>0$. □

Proof of Proposition 6: Let, as in the proof of Lemma 12, $W(\upmu)\equiv\mathbb{E}[u_C(\cdot)|r]$ be the CEO's indirect value function. We analyze whether an alternative convex hull exists such that the prior lies in the hull and a signal can be constructed from extreme points of the hull. By Carathéodory's theorem, concavification over a two-dimensional simplex is based on at most three linearly biased points. In our case, convex hulls created by triplets of linearly biased points are $\{ABD, ACD, ABC\}$. In addition, we have convex hulls constructed by pairs of points, i.e., lines. We proceed in two steps. First, we suppose that the prior is not on any line between points $\{A,B,C,D\}$, which is equivalent to be in the interior of Δ_{ABD} or in the interior of Δ_{ACD}. This eliminates convex hulls constructed by pairs of points. Second, we analyze the boundaries of Δ_{ABD} and Δ_{ACD}.

- For any prior in the interiors, $\upmu_0\in\text{int}(\Delta_{ABD})\cup\text{int}(\Delta_{ACD})$, the only alternative convex hull is Δ_{ABC}. Replacing $\widetilde{\upphi}$ (where $\widetilde{\upphi}=\upphi_{ABD}$ or $\widetilde{\upphi}=\upphi_{ACD}$) by $\upphi_{ABC}$ is equivalent to redistributing all probability mass $\widetilde{\phi}^D$ from point D to points B and C. The probability mass is divided into $(1-\mu_3^D,\mu_3^D)=(\mu_2^D,\mu_3^D)$ shares such that the martingale property is satisfied, $(1-\mu_3^D)\upmu^B+\mu_3^D\upmu^C=\upmu^D$. That is, $\upphi_{ABC}^B=\widetilde{\phi}^B+\mu_2^D\widetilde{\phi}^D<1$, $\upphi_{ABC}^C=\widetilde{\phi}^C+\mu_3^D\widetilde{\phi}^D<1$, $\phi_{ABC}^D=0$, and $\upphi_{ABC}=\widetilde{\upphi}$ otherwise. This redistribution decreases the CEO's objective,

$$\begin{aligned}\sum_{r\in\widehat{\mathbb{S}}}\upphi_{ABC}W(\upmu)-\sum_{r\in\widehat{\mathbb{S}}}\widetilde{\upphi}W(\upmu)&=\widetilde{\phi}^D[\mu_2^DW(\upmu^B)+\mu_3^DW(\upmu^C)-W(\upmu^D)]\\&=-\widetilde{\phi}^D(1-\mu_3^D)W(\upmu^B)<0,\end{aligned}$$

  because $\mu_2^o>0$ and $\mu_3^o>0$ (hence, $\widetilde{\phi}^D>0$), and $W(\upmu^B)=\theta_2-\theta_C>0$.

- Consider boundaries of the simplex. For $\mu_1^o=0$, we replicate the argument from above; redistribution of the probability mass from point D to points B and C decreases the CEO's objective as $W(\upmu^D)>\mu_2^DW(\upmu^B)+\mu_3^DW(\upmu^C)$. For $\mu_2^o=0$, all feasible signal distributions based on $\{A,B,C,D\}$ are exactly equivalent, $(\phi^A,\phi^B,\phi^C,\phi^D)=(\mu_1^o,0,\mu_3^o,0)$. The same holds for $\mu_3^o=0$, where $(\phi^A,\phi^B,\phi^C,\phi^D)=(\mu_1^o,\mu_2^o,0,0)$.

- The remaining case is when $\upmu_0$ is located on AD line but not on the boundary. Then, $\frac{\mu_2^o}{1-\mu_3^D}=\frac{\mu_3^o}{\mu_3^D}$, and $\upphi_{ABD}=\upphi_{ACD}$. No other distribution based on $\{A,B,C,D\}$ is feasible.

To sum up, none of the alternative concavifications over $\widehat{\mathbb{S}}$ is a solution to the CEO's linear programming problem in equation (4). □

Proof of Corollary 4: Follows directly from Proposition 6 and is omitted. □

Proof of Corollary 5: For a strong conflict ($\mu_0 \in \Delta_{ABD}$) we can coarsen the report realizations with interim beliefs μ^A and μ^B at points A and B leading to rejection, into a single realization with interim belief μ^L at point L, where

$$\mu^L = \frac{\widetilde{\phi}^A}{\widetilde{\phi}^A + \widetilde{\phi}^B}\mu^A + \frac{\widetilde{\phi}^B}{\widetilde{\phi}^A + \widetilde{\phi}^B}\mu^B.$$

The optimal 3D-distribution then is equivalent to a 2D-distribution ϕ_{LD} over a subset $\{L, D\}$ where

$$(\phi^L_{LD}, \phi^D_{LD}) \equiv \left(\phi^A_{ABD} + \phi^B_{ABD}, \phi^D_{ABD}\right).$$

For a weak conflict ($\mu_0 \in \Delta_{ACD}$) we can coarsen the report realizations with interim beliefs μ^C and μ^D at points C and D leading to approval, into a single realization with interim belief μ^H at point H, where

$$\mu^H = \frac{\widetilde{\phi}^C}{\widetilde{\phi}^C + \widetilde{\phi}^D}\mu^C + \frac{\widetilde{\phi}^D}{\widetilde{\phi}^C + \widetilde{\phi}^D}\mu^D.$$

The optimal 3D-distribution is equivalent to a 2D-distribution ϕ_{AH} over a subset $\{A, H\}$, where

$$(\phi^A_{AH}, \phi^H_{AH}) \equiv \left(\phi^A_{ACD}, \phi^C_{ACD} + \phi^D_{ACD}\right).$$

□

References

[1] Adams, R. B., Ferreira, D. 2007. A theory of friendly boards. *Journal of Finance*, 62(1), 217–250.

[2] Aghamola, C., Hashimoto, T. 2020. Aggressive boards and CEO turnover. *Journal of Accounting Research*, 50, 437–486.

[3] Antle, R., Eppen, G. 1985. Capital rationing and organizational slack in capital budgeting. *Management Science*, 31(2), 163–174.

[4] Arya, A., Glover, J., Sivaramakrishnan, K. 1997. Commitment issues in budgeting. *Journal of Accounting Research*, 35, 273–278.

[5] Associated Press. 2020. Report: Former Aluminum Mill CEO misled investors, board. April 27, 2020.

[6] Bagnoli, M., Watts, S. 2015. Delegating disclosure and production choices. *The Accounting Review*, 90, 835–857.

[7] Baiman, S., Heinle, M., Saouma, R. 2013. Multi-stage capital budgeting with delayed consumption of slack. *Management Science*, 59(4), 869–881.

[8] Baldenius, T. 2003. Delegated investment decisions and private benefits of control. *The Accounting Review*, 78(4), 909–930.

[9] Baldenius, T., Dutta, S., Reichelstein, S. 2007. Cost allocations for capital budgeting. *The Accounting Review*, 82(4), 837–867.

[10] Baldenius, T., Melumad, N., Meng, X. 2014. Board composition and CEO power. *Journal of Financial Economics*, 112(1), 53–68.

[11] Baldenius, T., Meng, X., Qiu, L. 2019. Biased boards. *The Accounting Review*, 94(2), 1–27.

[12] Baldenius, T., Meng, X., Qiu, L. 2021. The value of board commitment. *Review of Accounting Studies*, 26(4), 1587–1622.

[13] Ball, I., Gao, X. 2023. Benefiting from Bias: Delegating to Encourage Information Acquisition. Working paper.

[14] Baumol, W. 1959. Business behavior, value and growth. New York: Macmillan.

[15] Bastian-Johnson, N., Pfeiffer, T., Schneider, G. 2013. Multistage capital budgeting for shared investments. *Management Science*, 59, 1213–1228.

[16] Bastian-Johnson, N., Pfeiffer, T., Schneider, G. 2017. Two-stage capital budgeting under resource constraints. *Review of Accounting Studies*, 22, 933–963.

[17] Bernardo, A., Cai, H., Luo, J. 2001. Capital budgeting and compensation with asymmetric information and moral hazard. *Journal of Financial Economics*, 61(3), 311–344.

[18] Bertomeu, J., Cheynel, E. 2015. Asset measurement in imperfect credit markets. *Journal of Accounting Research*, 53 (5), 965–984.

[19] Bertrand, M., Mullainathan, S. 2003. Enjoying the quiet life? Corporate governance and managerial preferences. *Journal of Political Economy* 111 (5), 1043–1075.

[20] Brav, A. Jiang, W., Ma, S., Tian, X. 2018. How does hedge fund activism reshape corporate innovation? *Journal of Financial Economics*, 130, 237–264.

[21] Caplin, A., Dean, M., Leahy, J. 2019. Rational inattention, optimal consideration sets, and stochastic choice. *Review of Economic Studies*, 86(3), 1061–1094.

[22] Chakraborty, A., Yilmaz, B. 2017. Authority, consensus, and governance. *Review of Financial Studies*, 30(12), 4267–4316.

[23] Che, Y., Kartik, N. 2009. Opinions as incentives. *Journal of Political Economy*, 117 (5), 815–860.

[24] Chen, K., Guay, W., Lambert, R. 2020. Multidimensional corporate governance: The joint design of board structure and executive compensation. Working paper.

[25] Chen, Y., Laux, V. 2021. Overconfidence, manipulation, and board monitoring. Working paper.

[26] Cianciaruso, D., Marinovic, I., Smith, K. 2020. Information design in financial markets. Working paper.

[27] Decaire, H., Sosyura, D. 2021. Self-dealing in corporate investment. Working paper.

[28] Deloitte. 2015. Directors' Cut: Board Effectiveness. Available at: https://www2.deloitte.com/content/dam/Deloitte/au/Documents/risk/deloitte-au-risk-director-cut-310815.pdf

[29] Dessein, W. 2002. Authority and communication in organizations. *Review of Economic Studies*, 69, 811–838.

[30] Dewatripont, M., Titole, J. 1999. Advocates. *Journal of Political Economy*, 107(1), 1–39.

[31] Dordzhieva, A., Laux, V., Zhang, R. (2020). Signaling private information via accounting system design. Working Paper.

[32] Drymiotes, G. 2007. The monitoring role of insiders. *Journal of Accounting and Economics*, 44 (3), 359–377.

[33] Drymiotes, G. 2009. Managerial influencing of boards of directors. *Journal of Management Accounting Research*, 20, 19–45.

[34] Dutta, S. 2003. Capital budgeting and managerial compensation: Incentive and retention effects. *The Accounting Review*, 78(1), 71–93.

[35] Dutta, S., Fan, S. 2009. Hurdle rates and project development efforts. *The Accounting Review*, 84(2), 405–432.

[36] Dutta, S., Reichelstein, S. 2002. Controlling investment decisions: Depreciation-and capital charges. *Review of Accounting Studies*, 7(2–3), 253–281.

[37] Ebert, M., Schäfer, U. and Schneider, G. 2019. Information leaks and voluntary disclosure. Working paper.

[38] Faleye, O., Hoitash, R., Hoitash, U. 2011. The cost of intense board monitoring. *Journal of Financial Economics*, 101 (1), 160–181.

[39] Feng, F., Luo, Y., Michaeli, B. 2022. In search of a unicorn: Dynamic agency with endogenous investment opportunities. Working paper.

[40] Fershtman, C., Judd, K. 1987. Equilibrium incentives in oligopoly. *The American Economic Review*, 77(5), 927–940.

[41] Frenkel, S., Guttman, I., and Kremer, I. 2019. The effect of exogenous information on voluntary disclosure and market quality. *Journal of Financial Economics*, forthcoming.

[42] Friedman, H., Hughes, J., Michaeli, B. 2020. Optimal reporting when additional information might arrive. *Journal of Accounting and Economics*, 69 (2–3), 101276.

[43] Friedman, H., Hughes, J., Michaeli, B. 2021. A rationale for imperfect reporting standards. *Management Science*, 68(3), 2028–2046.

[44] Gentzkow M., Kamenica E. 2017a. Competition in persuasion. *Review of Economic Studies*, 84, 300–322.

[45] Gentzkow M., Kamenica E. 2017b. Disclosure of endogenous information. *Economic Theory Bulletin*, 5, 47–56.

[46] Gregor, M. 2020. Board directors under CEO's pressure: Misreading, misreporting, and dissent risk. Working paper.

[47] Gregor, M., Michaeli, B. 2023. Board compensation and investment efficiency. Working paper.

[48] Göx, R., Michaeli, B., 2019. Optimal information design and incentive contracts with performance measure manipulation. Working paper.

[49] Göx, R.F., Wagenhofer, A. 2009. Optimal impairment rules. *Journal of Accounting and Economics*, 48(1), 2–16.

[50] Harris, M., Raviv, A. 2008. A theory of board control and size. *Review of Financial Studies*, 21(4), 1797–1832.

[51] Hart, O. 1995. Firm, contracts, and financial structure. London: Oxford University Press.

[52] Heinle, M., Ross, N., Saouma, R. 2014. A Theory of participative budgeting. *The Accounting Review*, 89 (3), 1025–1050.

[53] Hope, O., Thomas, W. 2008. Managerial empire building and firm disclosure. *Journal of Accounting Research*, 46(3), 591–626.

[54] Huang, Z. 2016. Optimal reporting systems with investor information acquisition. Working paper.

[55] Jensen, M. 1986. Agency costs of free cash flow, corporate finance, and takeovers. *American Economic Review*, 76(2), 323–329.

[56] Jensen, M., Murphy, K. 1990. Performance pay and top-management incentives. *Journal of Political Economy*, 98(2), 225–264.

[57] Jiang, X., Stocken, P. 2019. Public communication between managers and analysts. Working paper.

[58] Jiang, X., Yang, M. 2017. Properties of optimal accounting rules in a signaling game. *Journal of Accounting and Economics*, 63, 499–512.

[59] Kamenica, E., Gentzkow, M. 2011. Bayesian persuasion. *American Economic Review*, 101(6), 2590–2615.

[60] Kamenica, E. 2019. Bayesian persuasion and information design. *Annual Review of Economics*, 11, 249–272.

[61] Kroszner, R., Strahan, P. 2001. Bankers on boards: Monitoring, conflicts of interest, and lender liability. *Journal of Financial Economics* 62 (3), 415–452.

[62] Laux, V. 2008. Board independence and CEO turnover. *Journal of Accounting Research*, 46(1), 137–171.

[63] Laux, V. 2014. Corporate governance, board oversight, and CEO turnover. *Foundations and Trends in Accounting*, 8(1), 1–73.

[64] Li, H. 2001. A theory of conservatism. *Journal of Political Economy* 109 (3), 617–636.

[65] Libgobber, J., Michaeli, B., Wiedman, E. 2023. With a grain of salt: Uncertain relevance of external information and firm disclosures. Working paper.

[66] Marris, R. 1964. The economic theory of managerial capitalism. London: Macmillian.

[67] Maffett, M., Nakhmurina, A., Skinner, D. 2022. Importing activists: determinants and consequences of increased cross-border shareholder activism. *Journal of Accounting and Economics*, 74 (2–3), 101538.

[68] Malenko, N. 2014. Communication and decision-making in corporate boards. *Review of Financial Studies*, 27(5), 1486–1532.

[69] Matysková, L., Montes, A. 2023. Bayesian persuasion with costly information acquisition. *Journal of Economic Theory*, 211, 105678.

[70] Meng, X. 2020. Information, incentives and CEO replacement. Working paper.

[71] Michaeli, B. 2017. Divide and inform: rationing information to facilitate persuasion. *The Accounting Review*, 92(5), 167–199.

[72] Mitusch, K., Strausz, R. 2005. Mediation in situations of conflict and limited commitment. *Journal of Law, Economics, and Organization*, 21(2), 467–500.

[73] Peterson, M. 2003. Kmart, saying ex-chief misled board, wants payments returned. The New York Times, February 26, 2003.

[74] Qiu, L. 2020. Say on pay and the "quiet life" of boards. Working paper.

[75] Rim, H., Sul, E. 2020. Director independence and corporate investment efficiency: Evidence from board reforms worldwide. Working paper.

[76] Segendorff, B. 1998. Delegation and threat in bargaining. *Games and Economic Behavior*, 23(2), 266–283.

[77] Shleifer, A., Vishny, R. 1989. Management entrenchment: The case of manager-specific investments. *Journal of Financial Economics*, 25(1), 123–139.

[78] Stulz, R. 1990. Managerial discretion and optimal financing policies. *Journal of Financial Economics*, 26(1), 3–27.

[79] The Economist. 2001. The fading appeal of the board room. March 31, 2001.

[80] Townsend, R. 1979. Optimal contracts and competitive markets with costly state verification. *Journal of Economic Theory* 21(2), 265–293.

[81] Useem, M. 2006. How well-run boards make decisions. *Harvard Business Review*, November 2016.

[82] Williamson, O. 1964. The economics of discretionary behavior: Managerial objectives in a theory of the firm. Englewood Cliffs, N.J.:Prentice-Hall.

IES Working Paper Series

2024

1. Nino Buliskeria, Jaromir Baxa, Tomáš Šestořád: *Uncertain Trends in Economic Policy Uncertainty*
2. Martina Lušková: *The Effect of Face Masks on Covid Transmission: A Meta-Analysis*
3. Jaromir Baxa, Tomáš Šestořád: *How Different are the Alternative Economic Policy Uncertainty Indices? The Case of European Countries.*
4. Sophie Ghvanidze, Soo K. Kang, Milan Ščasný, Jon Henrich Hanf: *Profiling Cannabis Consumption Motivation and Situations as Casual Leisure*
5. Lorena Skufi, Meri Papavangjeli, Adam Gersl: *Migration, Remittances, and Wage-Inflation Spillovers: The Case of Albania*
6. Katarina Gomoryova: *Female Leadership and Financial Performance: A Meta-Analysis*
7. Fisnik Bajrami: *Macroprudential Policies and Dollarisation: Implications for the Financial System and a Cross-Exchange Rate Regime Analysis*
8. Josef Simpart: *Military Expenditure and Economic Growth: A Meta-Analysis*
9. Anna Alberini, Milan Ščasný: *Climate Change, Large Risks, Small Risks, and the Value per Statistical Life*
10. Josef Bajzík: *Does Shareholder Activism Have a Long-Lasting Impact on Company Value? A Meta-Analysis*
11. Martin Gregor, Beatrice Michaeli: *Board Bias, Information, and Investment Efficiency*

All papers can be downloaded at: http://ies.fsv.cuni.cz

Univerzita Karlova v Praze, Fakulta sociálních věd
Institut ekonomických studií [UK FSV – IES] Praha 1, Opletalova 26
E-mail : ies@fsv.cuni.cz http://ies.fsv.cuni.cz