Shareholder Voice and Executive Compensation

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Abstract

How much does shareholder voice via non-binding Say-on-Pay votes impact executive compensation policy? Answering this requires understanding how much the *threat* of a failed vote impacts the Board of Directors. I estimate a model of CEO compensation with non-binding shareholder approval votes ("Say-on-Pay"). CEO pay is set by the Board, which is asymmetrically informed about the CEO, but biased towards offering a high wage. Shareholders can fail the Say-on-Pay (SOP) and punish the Board for overpayment. The estimation shows that failed votes are perceived as costly by both the Board and shareholders: a failure cost of 2.06% (0.76%) of value for the Board (shareholders) is sufficient to match observed pay levels and failure rates. Empirical evidence suggests the Board cost is a career and reputation concern for directors; for shareholders, it represents a cost to dissenting from the Board on a prominent policy. I construct a counterfactual SOP mechanism which emulates giving a focal shareholder an advisory seat on the Board; this lowers the SOP failure rate, decreases wages and increases firm value.

Keywords: shareholder voice, corporate governance, executive compensation, shareholder voting, say-on-pay, structural estimation

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1. Introduction

An important responsibility of the Board of Directors is to design executive compensation policy that aligns the interests of the CEO and shareholders. Yet the design of compensation is subject to an agency consideration — directors generally have an incentive to favor the CEO (Bebchuk and Fried, 2003). When shareholders disagree with CEO pay policy and exerting control is not possible, shareholders can convey their dissent by using their "voice" (Hirschman, 1970; Cuñat et al., 2016). Say-on-Pay (SOP), a non-binding shareholder approval vote on CEO compensation policy, is the primary channel through which shareholders can voice their dissent. While non-binding, SOP is in essence a vote of confidence on the Board's compensation decisions and the performance of the CEO. Given the importance and visibility of CEO compensation, SOP is a potentially important governance mechanism.

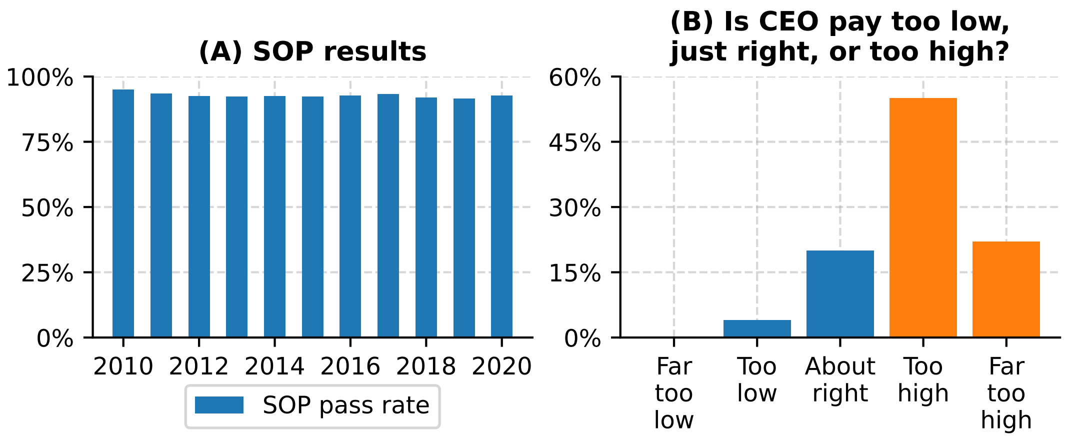
Yet the impact of SOP votes is unclear. Compensation policies receive over 90% support on average and only about 7% of SOP votes in the US fail.[1] As shown in the survey evidence in Figure 1, shareholders express dissatisfaction with CEO pay (Edmans et al., 2021), which is hard to square with the generally positive outcomes of SOP. Likewise, there are well-developed literatures studying CEOs' influence on the pay-setting process (e.g., Bertrand and Mullainathan, 2001; Morse et al., 2011; Coles et al., 2014) and CEOs' ability to demand a large share of rents (e.g., Gabaix and Landier, 2008; Custódio et al., 2013; Cziraki and Jenter, 2022), which are again hard to reconcile with such apparently high SOP support.

An important consideration is that SOP votes are *ex post* outcomes, occurring after the compensation contract has been set and firm performance realized. What matters is how much the Board internalizes the *threat* of SOP failure into their *ex ante* compensation decision; and, as Figure 1 suggests, it may be equally as important to understand shareholders' apparent hesitancy to fail SOP votes, even though they think CEOs are overpaid.

[1]SOP was introduced in the US as part of Dodd-Frank in 2010. SOP proposals are put forth by management at the annual shareholder meeting, and shareholders are asked to vote on the CEO's compensation from the just-passed fiscal year, *not* on the proposed compensation for the next year. Throughout the paper, I use "failure" to refer to SOP proposals that do not garner the required/expected majority support from shareholders. In the US, SOP votes are non-binding, so there is no threshold which forces management to change compensation policy. However, the widely understood threshold for SOP failure is 70% support (that is, 30% voting against, see ISS, 2022, Section 5 "Compensation"). 50% and 80% support are also important thresholds (Hauder, 2019). SOP votes are binding in other countries such as the United Kingdom. The analysis in this paper of non-binding SOP may not be directly applicable to those cases, even though the economic forces are likely similar.

Figure 1. Say-On-Pay results and shareholder satisfaction with CEO pay

This figure displays motivation for the paper. Panel A displays average SOP pass rates in the US by year from 2010 to 2020; it shows that the percentage of SOP votes that pass (garner over 70% support, see Appendix B) is about 93%. Panel B displays survey data from from Edmans et al. (2021), based on a question that asks UK institutional investors how they feel about the level of the CEO's pay; over 70% of survey respondents believe that their CEO is overpaid.



This paper's goal is to build a structural model to quantify the influence of SOP on CEO compensation and explore the mechanisms by which this influence occurs. In the model, the Board sets CEO pay every period and may be biased towards paying a large wage; this bias represents both CEO influence on the Board and CEO bargaining power over the firm. Shareholders decide whether to approve CEO pay (i.e., to pass or fail the SOP). Failure punishes the Board, yet is also (potentially) costly to shareholders.[2] Some CEOs are more skilled than others (equivalently, a better match for their firm), so their effort translates into higher output. The Board and shareholders cannot observe CEO skill, but learn it over time (like in Taylor, 2010), and can have different beliefs about the CEO's true ability. They learn by observing company productivity, with each further receiving a private signal. Importantly, the Board is asymmetrically informed (more precise beliefs) about the CEO's skill when they set the wage.

I estimate model parameters via the simulated method of moments and the model matches key moments. The model replicates the observed SOP failure rate very closely: 7% in both the simulated and real data; it also matches average CEO wages. Importantly, it matches the sensitivity of SOP failure likelihood to both the wage and company performance, the two primary determinants of SOP vote outcomes (Fisch et al., 2018).

[2]A common misconception about SOPs is that they are advisory votes on *proposed* compensation. Rather, they are *ex post* approval votes on the previous year's CEO compensation, hence the timing structure of the model (Appendix B and Novick, 2019).

The estimation produces several results. To match the data, boards must be biased towards overpaying CEOs (relative to the profit-maximizing, unbiased wage), which I refer to as *board capture*. I estimate that the average S&P1500 CEO captures 40.7% of the expected surplus produced by the firm, in line with Taylor (2013), who finds that CEOs capture half of the surplus from positive updates about their ability.

How does the seemingly low observed SOP failure rate square with a bias in the pay-setting process of this magnitude? My structural model provides an answer, considering the costs perceived by directors and shareholders from failed SOP votes. First, for SOP to impact compensation policy, it must be that the Board internalizes the threat of vote failure into their decision. To explain observed behavior, I estimate that Boards internalize a cost from SOP failure that is equivalent to 2.06% of firm value. While the unconditional failure rate of about 7% means the cost is about 0.14% of value in expectation, the (off-equilibrium) threat of costly SOP failure disciplines the Board's pay policy, even when failure is *ex ante* unlikely. My estimation shows that the existence of SOP brings CEO wages down by 4.4% on average.[3] Hence, *shareholder voice affects executive compensation policy.*

Second, failed SOP votes are perceived as costly by shareholders, contradicting the notion that SOP is a costless governance mechanism allowing shareholders to engage with the Board. I estimate that shareholders internalize a cost to SOP failure equivalent to 0.76% of value (about 0.05% in expectation unconditionally).[4] This aligns with survey evidence from Edmans et al. (2021): shareholders state that failing the SOP may be undesirable, for example because they are hesitant to publicly dissent from the Board on a prominent policy.[5]

SOP thus resembles a monitoring or evaluation mechanism with costly punishment (Silveira, 2017). Failed SOP votes punish the Board for overpayment, yet punishment is considered costly by shareholders. SOP is not just a vote on pay, but also akin to a performance evaluation of the Board, and my results show that shareholders internalize a cost to *giving* a negative evaluation.[6]

[3] My findings are in line with Correa and Lel (2016), who find that the introduction of SOP as a voice mechanism brought wages down by 7% on average in a cross-country analysis.

[4] That is, the cost is equivalent to 0.76% of each shareholder's equity stake in the firm.

[5] Shareholders may also wish to have a constructive relationship with management and prefer to address concerns through private engagement (Edmans et al., 2021). See Section 2.2 for a detailed discussion.

[6] In the performance review literature, this cost could reflect a *leniency bias* (Bol, 2011), which may arise due to a

To infer the magnitude of unobservable model parameters, the structural estimation uses observed, endogenous patterns in company performance, CEO pay and SOP vote outcomes. Its success hinges in part on whether there are sensible empirical patterns to reinforce the structural results. As described next, I document several fundamental empirical facts about CEO pay and SOP in support of the underling forces of the model.

The first set of new descriptive facts shows that SOP failure leads to negative effects for directors, in support of the magnitude of the Board's perceived cost. I find that failing a SOP is a career and reputation concern for directors. SOP failure is associated with a 2 percentage point (pp) increase in the likelihood that a compensation committee director leaves or is removed from the Board (a 20% larger likelihood of turnover relative to the non-fail group). For directors that remain on the board following SOP failure, I also find they are more likely to be removed or step down from the compensation committee — SOP failure is associated with a 1.5 pp increase in the likelihood they are removed from the compensation committee the next year (a 26% larger likelihood than the non-SOP-fail group).

Interestingly, I find that failed SOP votes lead to *external* reputational damage for directors. A failed SOP at a director's current firm is associated with a decrease in outside Board positions at other firms (a 2 pp increase in the likelihood that a director loses at least one outside board position). This evidence is in line with Fos and Tsoutsoura (2014) and Aggarwal et al. (2019, 2023), however to the best of the knowledge, my paper is the first to document such internal and external reputation costs to directors tied to SOP failure.

While directors generally wish to be re-appointed to the Board (the average director salary is around $400 thousand) I argue that a large portion of the Board's perceived SOP failure cost acts through a prestige channel (Fos and Tsoutsoura, 2014; Bebchuk and Fried, 2003). SOP failure is a public negative performance evaluation from shareholders on a prominent issue. Directors have an incentive to favor the CEO, and the threat of SOP failure pushes their incentives towards shareholders, even though failures rarely occur.

My estimation shows that SOP failures are perceived as costly by shareholders. From survey evidence in Edmans et al. (2021), shareholders state they avoid SOP failure to maintain

relationship between prominent shareholders and members of the Board, or from information-gathering costs (i.e., shareholders trust that the Board has better information and are hesitant to give a negative review).

relations with the Board; my results above show that SOP failure leads to director turnover. The negative performance evaluation aspect of SOP failure may commit shareholders to raising the rate of Board turnover, which *ex ante* may be undesirable.

Similarly motivated for the CEO, the model suggests that the SOP is about more than pay, it is a public signal revealing shareholder beliefs about the CEO's match with the firm; the model indirectly predicts that CEO turnover likelihood should be higher when SOPs fail. I find that the turnover rate is around 30% higher in SOP failure relative to pass (about 9% *vs.* 12%). Given costs associated with CEO turnover (Taylor, 2010), and increased uncertainty for the company and stock price (Clayton et al., 2005), this suggests a motivation for why SOPs do not fail: shareholders prefer to avoid the negative outcomes associated with CEO turnover.

More over, SOP shareholders likely cannot discern the separate roles hidden CEO influence from CEO bargaining power in inflating CEO wages (Bebchuk and Fried, 2003). SOP is designed to combat the former, yet granting CEOs a large share of surplus is likely optimal if it preserves or creates a match. The correlation between SOP failure and CEO turnover is consistent with shareholders internalizing this into their voting decisions.

I present empirical evidence of excess density in the distribution of SOP vote outcomes directly below important failure thresholds. In particular, defining SOP *dis*approval as one minus the proportion of shareholder that approve the SOP, I uncover bunching directly below the failure thresholds of 30% and 50%.[7] Bunching helps to identify the parameters which measure Board and shareholder costs from SOP failure. In the data, bunching just below the failure threshold is consistent with shareholders internalizing a cost from SOP failure. If blockholders, often pivotal in SOP votes, perceive a failure cost, they have an incentive to force a close pass relative to a close fail, as they do not want to deal with the public fallout or reputational damage arising from a failed vote (Edmans et al., 2021).

In the model, the shareholders' decision trades off the cost from increasing the probability of SOP failure (and facing their cost) against the benefits of forcing the Board to pay wages closer to the profit-maximizing level. As explained in Section 3, shareholders commit to an *ex ante* probability of failure by setting a threshold posterior belief, if the private signal they

[7] In SOP, 30% and 50% of shareholders voting against the SOP are key thresholds (Appendix B and Hauder, 2019).

receive pushes their beliefs below this threshold, the vote fails. Importantly, this threshold is itself a function of the wage (determined by the Board's private signal), so the Board too has an incentive to *bunch* wage choices if the benefit (decrease in probability that SOP fails) outweighs the cost (paying the CEO a lower wage) of such behavior. Bunching thus identifies both the Board and shareholder costs to SOP failure.

Similar empirical evidence has been found in Babenko et al. (2019) in the broader context of management proposals, however to my knowledge, I am the first to use it to identify vote failure cost parameters in a structural model.[8] Further, Babenko et al. (2019) focuses on company management undertaking steps to induce a close pass, consistent with the Board cost; I show how bunching helps identify the *shareholder* cost to failure.

Finally, to provide reduced-form evidence that the board bias I estimate is not merely CEO bargaining power, I analyze an important empirical measure of CEO influence used in the literature: board co-option as in Coles et al. (2014), which the authors measure as the proportion of the Board that has been appointed during the current CEO's tenure. CEOs may influence director selection (Weisbach, 1988), so board co-option measures CEO influence on the Board. Following Coles et al. (2014), I confirm that higher board co-option implies higher CEO pay. This result is robust to industry and time fixed effects, suggesting that observed board overpayment is not just a function of high CEO bargaining power (to the extent that these effects determine CEO outside options).[9]

Finally, the structural model allows me to go beyond estimating parameters and uncovering their implications: I can construct a counterfactual way of implementing SOP. In my baseline model, the Board and shareholders private information about the CEO determine wage and voting strategies, so SOP vote outcomes are determined in part by different beliefs about the CEO. A simple change to the way information is shared in my model emulates a commonly proffered way to engender communication and align beliefs between the Board and shareholders — granting a focal shareholder an advisory seat on the Board (Kakhbod et al., 2023).[10]

[8]This methodology has been used in the public finance literature (Saez, 2010; Chetty et al., 2011), and more recently in corporate finance (Antill, 2021; Ewens et al., 2023; Alvero et al., 2023).

[9]I further find that board co-option modulates the relation between *changes* in CEO pay and SOP outcomes. When SOPs fail, companies decrease their CEO's wage considerably on average; higher board co-option attenuates this relation towards zero. Board capture lessens the disciplining effect of SOP votes on wages.

[10]As explained in Section 6, this also emulates shareholders influencing *proposed* compensation policy.

In the model, this amounts to the Board and shareholders *sharing* their private signals (beliefs) about the CEO *in advance* of their decisions, as opposed to the wage and vote being determined by these private, possibly divergent signals. In this counterfactual, the SOP failure rate falls, wages decrease on average (though can increase, as explained in Section 6) and firm value increases on average. Importantly, this counterfactual does not involve changing estimated parameters, these effects are achieved solely by changing the way information is revealed within the model.

The rest of the paper is organized as follows. I first describe the paper's contribution and context within the literature. Section 2 describes the data and presents empirical facts about CEO pay and SOP, which both motivate and discipline the model. Section 3 presents the structural model. Section 4 describes the estimation methodology and identification, and Section 5 presents the results of the structural estimation. Section 6 analyzes counterfactuals based on the estimated parameters. Appendix B provides an institutional summary of SOP. Additional model results are in Appendix C and estimation details are in Appendix D.

1.1. Literature review

This paper contributes to the literature on shareholder voice as a way to influence corporate policies (e.g. Hirschman, 1970; Gillan and Starks, 2007). Levit and Malenko (2011) study non-binding votes as a form of communication, showing how a large (activist) investor can make votes more effective at influencing management. My paper estimates how much the Board internalizes the cost of failing a SOP and my subsample analysis shows that this cost varies with the presence of large shareholders. Levit (2019) studies the effectiveness of communication (voice) in influencing the decision-maker (the Board), which is directly related to the voice mechanism in my paper — the Board and shareholder costs to SOP failure determine the effectiveness of SOP as a communication device in disciplining wages. Kakhbod et al. (2023) studies how large, passive investors (for whom exit is not a viable path) can act as a coordinating force among the shareholder base.

My empirical results speak to the literature on how non-binding or non-consequential shareholder voting can influence the Board of Directors. Fos and Tsoutsoura (2014) study how proxy contests impact the careers of directors and Aggarwal et al. (2019) study the impact of dissent votes in uncontested director elections on careers; my paper shows the career and reputation consequences from a specific form of non-binding shareholder votes — SOP.[11]

My paper also contributes to the literature on Say-on-Pay. Several papers study how the implementation of SOP was valued by market participants (e.g., Cai and Walkling, 2011; Larcker et al., 2011; Ferri and Maber, 2013; Correa and Lel, 2016; Cuñat et al., 2016). These papers examine whether the increase in voice granted by the adoption of SOP leads to higher shareholder value. However, given the high SOP support, several papers (Armstrong et al., 2013; Kaplan, 2013) have concluded that, once implemented, SOP has not influenced compensation and questioned its effectiveness in practice. My paper shows that Boards do incorporate the threat of SOP failure into the *ex ante* compensation policy, even though the *ex post* observed SOP failure rate is low. Hence, SOP in practice does impact compensation policy.

My paper relates to how institutional investors impact executive compensation. Mehran (1995) and Hartzell and Starks (2003) show a negative relation between blockholder ownership and the level of CEO pay. SOP was introduced in the US explicitly to increase (large) shareholders' ability to monitor compensation policy. My estimates show that SOP is successful in lowering the level of CEO pay, yet SOP failure is costly to shareholders. Several papers have argued that passive investors, generally the largest blockholders, are ineffective monitors due to their tendency to vote with management (Heath et al., 2022). My results show that dissenting from management carries consequences. In subsample analysis, I show that large blockholders *are* effective monitors (the Board cost to SOP failure is larger), yet they also face a larger cost to SOP failure when they dissent from the Board. Hence, the argument that passive (large) investors are ineffective monitors is more subtle than previously considered.

The study of executive compensation from an empirical, theoretical, or structural perspective is too vast to properly reference here. Taylor (2010, 2013) and Page (2018) are seminal structural papers studying CEO compensation, CEO turnover and Board incentives. Lyman (2023) studies CEO turnover and CEO pay policy jointly in a structural model. A structural literature that studies shareholder voting has emerged; e.g., Blonien et al. (2022) study errors

[11] Aggarwal et al. (2023) study shareholders' motivations for voting against corporate directors and find that shareholders hold directors accountable for a wide range issues, with governance being the main driver.

in shareholder voting, Pinnington (2022) considers strategic effects in determining passive funds' management biases. To the best of my knowledge, this is the first paper to estimate a structural model of executive compensation with a shareholder vote.

Finally, SOP can be seen as a monitoring mechanism with costly punishment. While non-binding in the sense that there is no explicit consequence, the Board's punishment for a negative evaluation arises through a *career concern* or *reputation* channel (Dewatripont et al., 1999). The shareholder cost resembles a hesitancy for the evaluator the give a negative review, which has been explored in the performance evaluation literature (e.g., Bol, 2011). Similar economic settings have been explored in the empirical industrial organization literature, for example Silveira (2017) studies how the threat of trial sentencing (and costs associated for both sides) lead to most criminal cases ending in a plea bargain, and Blundell et al. (2020) study how the threat of costly regulatory scrutiny curbs pollution.

2. Empirical Analysis of CEO Compensation and Say-on-Pay

2.1. Data

For the analysis in Section 2.2 and the estimation described in Section 4, I use data on SOP vote results (Institutional Shareholder Services), CEO compensation (Execucomp), firm accounting data (Compustat), and stock prices (CRSP). The period is 2011-2020, and the sample is S&P1500 firms as I do not observe detailed executive compensation and voting data beyond this group.

Table 1 displays summary statistics for the empirical sample. It displays statistics for firm-level variables, CEO-level variables and outcome of SOP votes. The average vote against is about 9% (i.e., the average support rate is about 91%). Only 6.8% of votes fail (have more than 30% vote against), and 1.8% receive less than 50% support. Firms are on the larger end (due to the focus on S&P1500 firms), so there is a significant right skew in size and revenues.

The average CEO in the sample receives $855 thousand in salary, and $138 thousand in bonus. However, bonus is not a strong feature of the sample, with only 15% receiving a bonus greater than zero. An important thing to note — the model is silent on long-term equity compensation, see Page (2018) for structural analysis of the CEO's contract. CEO tenure is 7 years at the median, which will inform the separation probabilities in the estimation.

2.2. Empirical Facts

This section documents key empirical facts about SOP outcomes and executive compensation that help motivate and discipline the model. Specifically,

1. The probability of SOP failure is driven primary by CEO pay and company performance; CEO pay decreases following failed SOP votes.
2. CEOs exert influence over compensation policy via *board capture*.
3. SOP disapproval leads to costly outcomes for directors.
4. SOP voting behavior is consistent with shareholders facing a cost from SOP failure.

Facts 1 and 2 are largely a summary of empirical results known to the literature, collected and framed within my setting, whereas Facts 3 and 4 are new results that motivate the Board and shareholder costs to SOP failure.

Fact 1. *SOP failure likelihood increases in the level of CEO pay and decrease in company/stock performance; CEO pay decreases dramatically following SOP failure.*

This introductory fact clarifies two important features of SOP and provides a basis for analysis. First, SOP votes are driven by two main forces — the probability of SOP failure is increasing in the level of CEO's wage, and decreasing in company and stock performance. Second, SOP does correlate with changes in compensation policy — CEO pay falls when SOP votes fail.

Table 2 Panel A displays regressions in which the dependent variable is an indicator for SOP failure (more than 30% voting against the SOP, in columns 1-4), or the percentage of shareholders voting against the SOP (the continuous measure, columns 5-8). The main independent variable is log current CEO compensation. The table shows that SOP failure likelihood and SOP disapproval rates are strongly increasing in the level of CEO wages. This relation is robust to performance controls and fixed effects (even as fine as firm × CEO), as well as lagged pay.

The same panel shows that SOP disapproval is *decreasing* in company and stock performance (the firm's return on assets (ROA) and the 12-month stock return, respectively), conditional on the CEO's pay, confirming findings from Fisch et al. (2018).[12] These strong relations provide clarification for the quantitative model. Shareholders fail SOPs when wages are (too)

[12] Table A.1 tests the company/stock performance hypothesis separately.

high, given what they believe about the CEO. If the company is doing well, then shareholders are less likely to fail the SOP, even if wages are high. Both of these forces will inform the structure of the SOP vote in the model.

While Panel A of Table 2 shows that shareholders respond to the level of wages and company performance, it is not clear whether the Board changes pay policy in response to negative SOP outcomes. Panel B displays the results of a regression of year-on-year changes in CEO compensation (from t to $t + 1$) on the SOP vote result from the previous year (t). The table shows a strong negative relation between changes in CEO pay and SOP disapproval.[13] This table shows that changes in pay policy are associated with SOP disapproval, suggesting that SOP does play a role in compensation policy.

Fact 2. *CEOs exert influence over their compensation via* board capture.

CEOs can partially determine the compensation-setting process by influencing the Board of Directors.[14] Concurrently, CEOs have bargaining power over the firm (Gabaix and Landier, 2008; Taylor, 2013; Cziraki and Jenter, 2022). If inflated wages are primarily the latter, then they may be optimal, so confirming the presence of the former in my data (which SOP is designed to combat) is important.

I examine a well-established measure from the literature: *board co-option* (Coles et al., 2014), which measures percentage of directors (including independent) that were appointed within the CEO's tenure. Coles et al. (2014) show that board co-option correlates with the level of CEO pay for the full sample of Execucomp firms. In Table 3 Panel A, I confirm this relation in my data. The level of CEO pay increases with board co-option. As in Coles et al. (2014), I include CEO tenure fixed effects in each specification as co-option mechanically rises with tenure. The table predicts that CEO compensation increases by 7-9 percentages points for each standard deviation increase in board co-option.

[13]The change in CEO compensation is about four percentage points lower following SOP failure (columns 1-4). Similarly, columns 5-8 show that a one standard deviation in the percentage of shareholders that vote against the SOP is associated with about a 1.5 percentage point smaller change in CEO pay. This relation is robust to performance controls and firm × CEO fixed effects, and the inclusion of the previous level of CEO pay.

[14]This is a developed literature, starting with Bebchuk and Fried (2003), who argue that compensation policy design itself is subject to agency problem. For studies of CEO influence on directors, see Weisbach (1988); Hermalin and Weisbach (1998, 2001); Taylor (2010); Coles et al. (2014). For studies of CEO influence directly on pay-setting, see Crystal (1992); Mehran (1995); Bertrand and Mullainathan (2000, 2001); Adams et al. (2005); Kuhnen and Zwiebel (2008); Morse et al. (2011); Goldman and Huang (2015); Page (2018); Edmans et al. (2021).

Panel B of Table 3 presents a result new to the literature. I regress log changes in CEO pay (from t to $t + 1$) on an interaction between board co-option and the outcome of the SOP vote (both from year t). The table shows that board co-option modulates the relation between changes in CEO pay and SOP disapproval. In other words, higher board capture lessens the influence that SOP has on compensation policy.[15]

The model incorporates CEO influence on the Board directly into the Board's pay-setting process. In the model, the Board wants to overpay the CEO by a constant proportion (determined by a parameter λ, which will be discussed in detail in Section 3). However, as I show in Appendix C.1, board capture in the model represents both CEO influence and CEO bargaining power, and neither the shareholder nor the econometrician is able to separately identify them.

Fact 3. *SOP failure correlates with costly outcomes for directors.*

A basic premise of the model is that SOP failure is costly for directors. I provide new evidence of this cost in three areas. First, Table 4 Panel A shows that SOP disapproval correlates with director turnover. I identify turnover events occurring between SOP votes and regress a director turnover indicator on the SOP vote result from the previous year.[16] Columns 1-3 of Panel A show that the likelihood that a director is turned over is between 1.5 and 2.3 percentage points (pp) higher after a SOP vote failure. Relative to non-SOP failure, the probability of director turnover is 20% higher. This finding is robust to controlling for company performance (ROA and firm's stock return over the past 12 months), along with a battery of controls covering board composition, and director and CEO features. Columns 4-6 show that increase in the percentage of shareholders disapproving the SOP also correlates with director turnover.

Panel B of Table 4 presents a second cost to directors from SOP disapproval. Focusing on the subsample of directors that remain on the board (i.e., directors not turned over), I identify cases where compensation committee members voluntarily or involuntarily leave their role on the compensation committee. I then correlate this compensation committee turnover with measures of SOP disapproval, as in Panel A. SOP failure is associated with a 1.1-1.5 pp higher

[15]Figure A.2 illustrates the results of Table 3. Panel A displays a binned scatterplot of log CEO pay on board co-option; Panel B displays how board co-option modulates the effect of SOP disapproval on compensation policy. The relation between changes in CEO pay and the percentage of shareholders voting against in SOP varies greatly going from zero to full board capture.

[16]Director turnover is identified following the methodologies in Fischer et al. (2009) and Iliev et al. (2015).

probability of being removed from or leaving the compensation committee. Relative to non-SOP failure, this is a 26% increase.

Panels A and B of Table 4 present evidence that SOP disapproval affects the careers of directors at the firm where SOP disapproval takes place. Panel C shows a third cost to directors by evaluates how SOP disapproval affects the *external reputation* of directors — via its effect on the number of outside Boards that the director sits on. In particular, I focus on compensation committee directors that sit on at least one outside board the year the SOP vote takes place. I then identify directors that see a reduction in outside Board seats from t to $t+1$. The Panel shows that SOP failure is associated with a $1.7-1.9$ pp increase in the likelihood that the director loses at least one outside Board position. Failing the SOP impacts directors *outside of the firm where they work* — reputation costs from shareholder disapproval of compensation policy affects a director's ability to sit on outside boards.

Table 4 shows that failing SOP votes presents a career concern for directors. In the model, SOP impacts CEO pay policy as shareholders can *threaten* the Board with the (off-equilibrium) cost from SOP failure. The evidence suggests that the cost (labeled χ_B) is large.

These findings are consistent with evidence from Fos and Tsoutsoura (2014) and specifically Aggarwal et al. (2019), who find that dissent votes in uncontested director elections lead to negative consequences for directors. My results are more directed, focusing on directors that serve on compensation committees, and the effect of SOP disapproval on re-appointment and reputation; they suggest that SOP disapproval leads to negative outcomes for directors.[17]

Fact 4. *SOP voting behavior is consistent with shareholders facing a cost from SOP failure.*

This paper explores the idea that failed SOP votes are perceived as costly by shareholders, with the goal of estimating the magnitude of this cost and exploring its importance in determining SOP votes and compensation policy. Edmans et al. (2021) provide survey evidence that this costs exists: in interviews, institutional investors express their reluctance to fail SOP

[17] Cost to SOP failure can also be gleaned directly from evidence (both empirical and anecdotal) of firms adjusting their compensation policies *in advance* of SOP laws being implemented. Correa and Lel (2016) show that, in response to the adoption of SOP laws around the world, firms lowered CEO pay — suggesting Boards internalize the likelihood of SOP failure into their compensation objectives. Dowell and Lubin (2011) give a specific example of GE altering the compensation policy of their CEO in advance of the introduction of SOP.

votes.[18] Failed SOP costs are viewed as a reputation cost, via dissenting from management on such a prominent and important firm policy. Additionally, shareholders feel that dissent constitutes a future monitoring cost, as management will repeatedly contact shareholders to discuss changes in compensation policy.[19]

In the model, SOP failure occurs when the Board and shareholders disagree about CEO ability. The model thus suggests that a low level of SOP support signals shareholder dissatisfaction with the CEO. That is, they believe the CEO's ability to run the firm is low relative to what the Board believes. In other words, SOP is about more than just pay, it is also a referendum on the CEO's ability to run the firm. Given this vote of "no confidence" in the CEO, a sensible implication from the model is that CEO turnover likelihood should be higher when there is low SOP support.

Changing the CEO is a significant event in the life of a firm. Taylor (2010) estimates that CEO turnover costs the equivalent of 1.3% of firm assets, and Clayton et al. (2005) show that CEO turnover leads to long-term increases in stock return volatility. For shareholders, avoiding these downsides may be preferable to exerting more control on CEO wages. As such, if SOP failure leads to the CEO being replaced, it may be preferable to pass the SOP.

Table 5 shows that SOP disapproval is associated with increases in the likelihood of CEO turnover. When the SOP fails, the CEO is 2.3 to 3.2 percentage points more likely to be turned over, about a 30% increase relative to turnover rate when SOPs pass. The table also shows that CEO turnover likelihood increases by about 0.8 percentage points for a standard deviation increase in the percentage of shareholders voting against the SOP.

While the survey and CEO-turnover based evidence are suggestive of the existence of a cost to shareholders from failing SOPs, I can use bunching of vote outcomes below SOP failure thresholds to reveal information on this cost. A higher occurrence of close passes relative to fails suggests that shareholders strategically avoid failing SOPs.[20]

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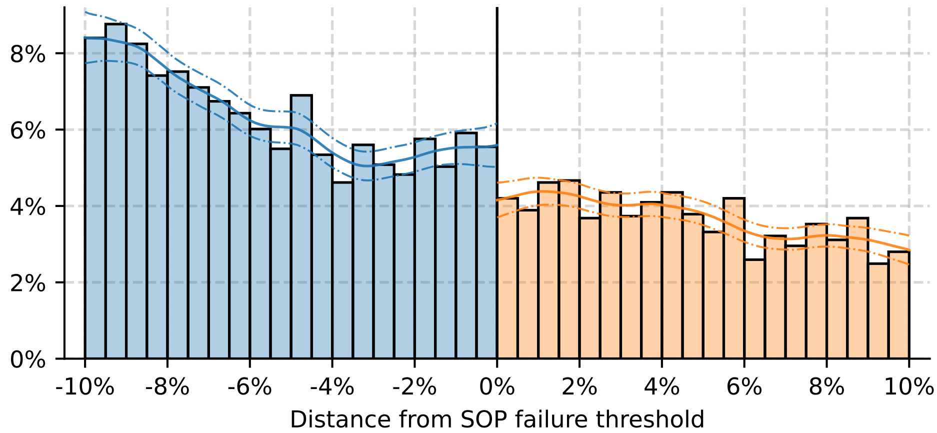
[18] It is important to note that Edmans et al. (2021) survey UK institutional investors, so the respondents are not discussing their views on SOP in the US. SOP votes in the US and UK receive similar levels of support.

[19] This evidence is taken from Online Appendix A of Edmans et al. (2021). Investors also mentioned that they often follow proxy advisors, as resource constraints prevent them from fully analyzing compensation policy. I present anecdotal evidence of future monitoring costs using the 2022 Netflix proxy statement in Figure A.1. After failing the 2021 SOP, Netflix engaged with large shareholders about compensation numerous times throughout the year.

[20] This type of strategic behavior requires coordination across diffuse shareholders, or the presence of blockhold-

Figure 2. Density manipulation of SOP outcomes

This figure displays the results of testing for density manipulation of SOP disapproval at the failure threshold of $\tau = 30\%$, following the methodology described in Cattaneo et al. (2018). In particular, I look for bunching at τ in $\Delta^{\text{data}} = \text{share against} - \tau, \quad \Delta^{\text{data}} \geq 0 \iff$ SOP fail. I focus on SOP votes falling within 15% of the failure threshold. I test for density manipulation of Δ^{data} 0. The blue and orange bars display observed frequencies of Δ^{data} in 0.5% bins ranging from -10% to $+10\%$. The blue and orange lines (and shaded areas) display the estimated local-polynomial densities. To estimate the densities, I set the order of the local polynomial (and the order of the bias-corrected density estimator) equal to 1.



I test for density manipulation (Cattaneo et al., 2018) around the important SOP failure thresholds of 30% and 50%, the commonly understood thresholds for SOP failure (ISS, 2022). Figure 2 displays the result. The light blue and orange bars show the observed frequencies of SOP vote outcomes in 0.5 percentage point relative to the failure threshold.[21] There is clear bunching, and I find a statistically significant difference in density (Cattaneo et al., 2018).[22]

Although density manipulation is not definitive evidence of a shareholder cost from failed SOP votes, the presence of discontinuity at the failure threshold is consistent with this cost. Blockholders, who are key to the outcome of the vote, have an incentive to pass the vote, even if they believe the CEO's wage is too high. Further, bunching at the failure threshold may provide information on how costly failed votes are to Boards, who can also alter compensation policy to swing a close fail to a close pass. This is explored in Babenko et al. (2019), in which the authors find systematic evidence of management influencing the outcome of close votes.

ers. Given the prevalence of blockholder owners in US firms, the latter seems likely — large pivotal blockholders can effectively swing the outcome of a vote by strategically keeping the percentage of votes against the SOP below failure threshold.

[21] See Cattaneo et al. (2020) and Cattaneo et al. (2021) for details. The figure focuses on votes with greater than 20% share of votes against and at most 40% (for the threshold of 30%, and greater than 40% and at most 60% for the 50% threshold

[22] Appendix Figure A.3 conducts a test where I set "placebo" vote failure thresholds of 20% and 40%, as opposed to the commonly accepted thresholds of 30% and 50%. The figure shows no change in density at these thresholds.

To further motivate the existence of costs to SOP failure, in Appendix **??**, I present a simple structural model (independent of the model in Section 3) which uses the observed bunching in Figure 2 to estimate an object related to the cost of SOP failure. Importantly, this simple model does not place enough structure on the data and *cannot separately identify* the Board and shareholder costs to SOP failure: the object I estimate maps to a combination of the two. Nevertheless, the outcome of the estimation in Appendix **??** is similar in magnitude to the costs I estimate in Section 4 (both Board and shareholder), which is reassuring.

The identification of the model's SOP failure cost parameters relies on how the votes are distributed around the SOP failure threshold. In the model, which will be explained in detail in Section 3, shareholders take into account the discrete disutility cost of a failed vote*vs.* its impact on the Board's wage decision when SOP failure is more probable. In turn, the Board is aware of the distribution of shareholders' beliefs and understands that in some states, even slight reductions in wages can significantly reduce the likelihood of the vote failing. While the underlying signal distributions for both parties are continuous, the model predicts that there will be a clustering of vote outcomes directly below the failure threshold with a corresponding gap in the distribution directly above it. The magnitude of the empirical discontinuity will be used to identify the key failure cost parameters in the model.

The evidence in this section presents several new stylized facts about CEO pay and SOP vote outcomes. These facts discipline the model in Section 3, and inform the identification and estimation in Section 4. Particularly important are the motivations for the model parameters which embed the Board's bias towards over-paying the CEO (board capture), and the magnitude of the Board and shareholder cost arising from SOP failure.

3. Model

This section outlines the model. The key forces are guided by the analysis in Section 2. The subsequent estimation will determine the extent to which these forces matter; for now, the model treats them as parameters. Table A.2 displays model parameters and definitions. The framework, in particular the belief formation process, is inspired by Taylor (2010).

3.1. Technology and Environment

Time is annual and the firm is infinitely-lived.[23] Each firm consists of a Board of directors, a shareholder base, and a CEO. The Board sets the CEO's wage each period, shareholders hold an approval vote of the Board's pay policy (a "Say-on-Pay"), and the CEO exerts effort for the wage they receive. CEO skill is uncertain — the Board and shareholders form beliefs based on the information they observe. Each period, a CEO of tenure τ separates from the firm with (exogenous) probability $f(\tau)$; upon separation, the firm matches (exogenously) with a new CEO.

Effort (n_t) is increasing but concave in the wage w_t,

$$n_t = w_t^{\gamma}, \quad \gamma \in (0, 1).$$

This assumption captures in reduced-form that effort is privately costly for the CEO, so compensation extracts less effort if effort is already high. The firm produces according to

$$y_t = A_t n_t^{\beta}, \quad \beta \in (0, 1),$$

where β is a constant and $A_t > 0$ is the firm's productivity. I am not interested in separately identifying γ and β, so I define $\alpha \equiv \gamma\beta \in (0, 1)$ to describe the shape of the firm's production function.[24] Output is thus

$$y_t = A_t w_t^{\alpha}. \tag{1}$$

Idiosyncratic productivity is centered around a, the CEO's skill, but influenced by a mean-zero shock ε_{yt},

$$\ln A_t = a + \varepsilon_{yt}, \quad \varepsilon_{yt} \sim N\left(0, \sigma_y^2\right). \tag{2}$$

[23]Though SOPs only need to occur once every three years, in practice most firms have them annually. I abstract away from this — if a firm has an SOP every two year three years, in the data analysis, I take only the year that an SOP occurs (rather than averaging across years), but either method works just as well.

[24]The CEO is largely a passive actor within the model and this assumption makes the model silent on the contracting problem between the Board and the CEO. Page (2018) estimates the effect of CEO attributes and agency issues on the CEO contract (salary and equity compensation). I shut this valve off and focus more so on the interaction between shareholders and the compensation committee. Appendix C.1 presents a simple micro-foundation of the relation between CEO effort, wage and output.

Type a is not observed by the Board and shareholders, they make predictions about a based on information they observe. Eq. (2) defines the notion of CEO skill — higher types achieve higher average productivity. Net operating income in year t is revenue minus the CEO wage:[25]

$$\pi_t = A_t w_t^{\alpha} - w_t.$$

The Board of Directors (B) sets the wage w_t. Importantly, the Board does not perfectly maximize firm profits. That is, absent dynamic considerations and any influence from the SOP, the Board would choose w_t to maximize

$$\pi_t^{\mathrm{B}} = A_t w_t^{\alpha} - (1-\lambda) w_t,$$

where $\lambda \in [0,1)$ governs the influence the CEO has on the Board's decision making, and more generally captures agency costs in the form of CEO influence on pay, what I refer to as *board capture* (see Section 2.2 and Fact 2). When $\lambda > 0$, the Board's optimal wage is above that which maximizes net operating income.[26] This bias can reflect a large outside option or some other channel which allows CEOs to demand a high wage (Cziraki and Jenter, 2022; Gabaix and Landier, 2008). It can also reflect CEO influence on the pay-setting process, for example via personal relationships with members of the Board (Coles et al., 2014). The model does not attempt to separate these forces, and in Appendix C.1 I show they are in fact not separately identified; rather λ measures a gap between the wage that would maximize shareholder value and the wage the Board would pay the CEO.

As Taylor (2013) shows, CEO wages (in expectation) display *downside rigidity* — risk averse CEOs accept lower wages in expectation if they are protected from downside risk. To match observed patterns in CEO compensation, the model needs to incorporate this aversion into the Board's problem. I include an adjustment cost which forces smoothness in CEO wages:

$$AC(w_t; w_{t-1}, \tau) = c_w \times w_t \left(\frac{w_t - w_{t-1}}{w_t} \right)^2 \times \mathbb{1}[w_t < w_{t-1}] \times \mathbb{1}[\tau > 0]. \tag{3}$$

[25]Profits (by assumption) are paid out immediately as dividends (including negative profits), and thus firm size is fixed over time and will not factor into the model (Taylor, 2010).

[26]I could write biased operating income as $(1-\nu)(A_t w_t^{\alpha} - w_t) + \nu w_t$, so the Board maximizes a weighted average of profits (shareholder value) and the extra wage it pays the CEO. It is equivalent to define $\lambda = \frac{\nu}{1-\nu}$.

Following Barrero (2022), the adjustment cost is quadratic in the wage and scales with wage levels, and only activates if the Board decreases the wage from $t-1$ to t; c_w controls how costly adjustment is, and is a parameter to be estimated. The one-sidedness of the cost is chosen to match the observed downside rigidity in CEO wages, as in Figure A.5. Further, the adjustment cost does not activate for CEOs in their first year of office, hence the indicator function for CEO tenure being greater than zero.[27]

Shareholders hold an approval vote each year on the Board's CEO pay policy, or a Say-on-Pay (SOP).[28] This vote is non-binding (it does not force the Board to set a new wage contract) and occurs at the end of each period (after the wage decision and output have occurred). I assume that a failed vote results in a cost for the Board: $\chi_B \geq 0$. In practice, this cost may include both pecuniary and non-pecuniary components, but in the model it measures the Board's (perceived) aversion to a failed vote. The Board's per-period utility is

$$A_t w_t^{\alpha} - (1-\lambda)w_t - \chi_B \times \mathbb{1}[\text{SOP fail}_t] - AC(w_t; w_{t-1}, \tau). \tag{4}$$

Shareholders in the model seek to maximize net operating income. Thus, if wages are "too high" given shareholders' current beliefs about CEO ability, the SOP vote may fail and the Board must incur the failure cost. Upon vote failure, the shareholders will also face a failure cost. As discussed in Section 2.2, such cost might represent an aversion to dissenting from the Board on compensation policy.[29] The parameter $\chi_S \geq 0$ governs the shareholders' cost of failing the SOP. The shareholders' per-period utility is

$$A_t w_t^{\alpha} - w_t - \chi_S \times \mathbb{1}[\text{SOP fail}_t]. \tag{5}$$

Eqs. (4) and (5) summarize the differences in Board and shareholder preferences: the Board is biased towards paying a higher wage, their SOP failure costs may differ, and the Board

[27]In tandem, Table 2 and Figure A.5 show why the adjustment cost is needed. The table shows that CEO pay falls when SOPs fail, whereas the figure shows that CEO wages rarely decrease. SOP failure *forces* the Board to alter their compensation policy and face the negative effects of lowering the CEO's wages.

[28]While the structure of the CEO's pay package certainly influences SOP outcomes, shareholders predominantly vote in response to the level of CEO pay, as detailed in Fact 1 and Table 2 Panel A.

[29]Like the Board cost, in the model, the cost is a perceived aversion to failing the SOP.

incorporates the one-sided adjustment cost.[30] Shareholders can alleviate the Board's bias (λ) by threatening to fail the SOP and forcing the Board to pay a (perceived) cost (χ_B); however they also internalize their own (perceived) cost from failed SOP votes (χ_S). The parameters χ_B and χ_S and their respective magnitudes will be the focus of the estimation.

3.2. Model Timeline, Signals and Beliefs

This section describes the per-period timeline of the model and the points at which the Board and shareholders receive information which updates their beliefs about the CEO. The per-period sequence of events in the model is displayed in Figure 3. CEO skill a is not known — the Board and shareholders observe information and update their beliefs about a. Upon separation from the current CEO, the firm matches with a new CEO of tenure $\tau = 0$, and the Board and shareholders start with a normally distributed prior about the CEO's skill,

$$a \sim N\left(\mu_0, \sigma_0^2\right), \tag{6}$$

which matches the distribution of ability in the CEO talent pool. At the annual compensation committee meeting, the Board receives their private signal about the CEO,

$$z_{bt} = a + \varepsilon_{bt}, \quad \varepsilon_{bt} \sim N\left(0, \sigma_{z_b}^2\right). \tag{7}$$

The signal z_{bt} can be thought of as *operational interaction* with the CEO and it will inform the Board's wage decision. Shareholders do not observe z_{bt}, which means that the Board is asymmetrically informed (has more precise beliefs) about the CEO when they set the wage. However, the Board must still make a prediction about the firm's productivity (eq. 2). The full description of the Board's wage decision is left to Section 3.4, but once set, the CEO receives their wage and exerts effort, and output and productivity realize.

At the annual shareholder meeting, each shareholder in the continuum of shareholders draws a signal about CEO type that is private knowledge, but correlated across shareholders.

[30] The assumption that shareholders do not incorporate the adjustment cost is crucial to keeping the shareholders' problem static, which simplifies the numerical solution. Moreover, Table 2 Panel A shows that lagged log pay does not have an impact on SOP outcomes, hence it is likely that shareholders vote in a “static" sense.

The standard voting model with incomplete information assumes that signals are completely private. However, in shareholder voting, signals are correlated (this correlation could reflect, e.g., proxy advisors' recommendations.) This correlated signal structure among the firm's shareholders makes it informationally equivalent (from the econometrician's perspective) to focus on a representative shareholder S, as microfounded in Appendix C.2.[31] Given this assumption, I henceforth refer to the single representative Shareholder, labeled S.

At the annual shareholder meeting, which occurs at the end of each period t, S aggregates information from the shareholder base into the signal:

$$z_{st} = a + \varepsilon_{st}, \quad \varepsilon_{st} \sim N\left(0, \sigma_{z_s}^2\right). \tag{8}$$

At the same point, S receives the firm's 10-K and proxy statement, which reveal output y_t, realized productivity A_t and the CEO's wage w_t. Importantly, A_t serves as a public signal about the CEO's ability — when productivity is high (eq. 2), B and S will revise their beliefs about the CEO upward. I label this signal:

$$z_{yt} = \ln A_t = a + \varepsilon_{yt}, \quad \varepsilon_{yt} \sim N\left(0, \sigma_y^2\right). \tag{9}$$

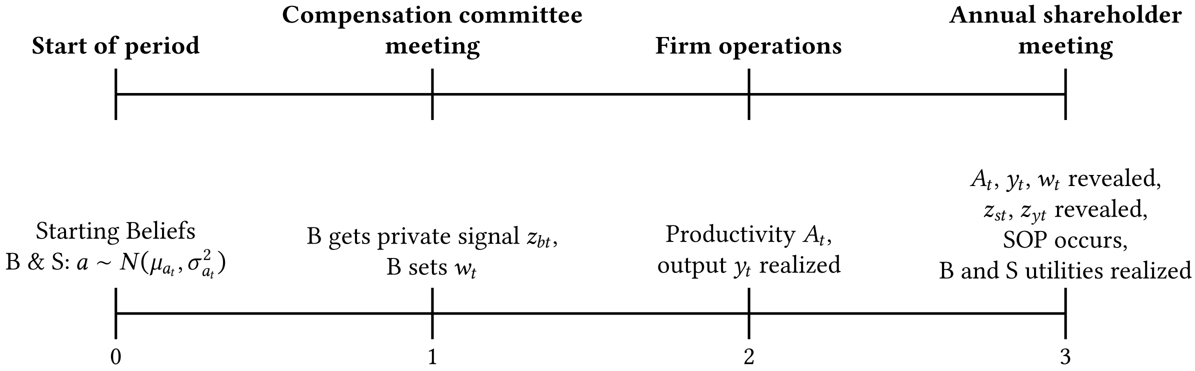
As will be explained in Section 3.3, both the private signal z_{st} and the public signal z_{yt} will affect the outcome of the SOP vote.

Model timeline. Figure 3 displays the sequence of events within the model. At the start of each period, B and S each believe that CEO ability $a \sim N\left(\mu_{at}, \sigma_{at}^2\right)$. As described in Appendix C.4, due to signal disclosure in the wage-SOP game, B and S share the same beliefs at the beginning of each period because B's wage choice fully reveals their private signal and the outcome of the SOP vote fully reveals S' signal.

[31] When all atomistic shareholders receive a correlated signal and vote with the same threshold strategy, there is informational equivalence in focusing on a representative shareholder that aggregates information across the shareholder base into a single signal and votes with the same threshold strategy. Further, this assumption of correlated private signals also embeds proxy advisors into the model. If a proxy advisor gives a negative recommendation, this is like a strong, negative signal of CEO ability. While I remain largely silent on the role of proxy advisors in the SOP process, I do acknowledge their importance. Lastly, It is important to note that this assumption about the shareholder base means influence of blockholder incentives on the SOP process, which undoubtedly play role, are outside the model.

Figure 3. Model timeline

This figure displays the within-period model timeline. The top timeline displays the timeline as it maps to practice; the bottom as it maps to the sequencing of events within each period t. Figure A.6 displays an in-depth timeline which incorporates the timing of the strategies by the Board and Shareholder (See Appendix C.4).



At the compensation committee, B receives their signal z_{bt}, which informs their wage decision. Then, operations take place — the CEO receives their wage and expends effort, and output and productivity realize. At the annual shareholder meeting, S receives the private signal z_{st}, and output, productivity and wages are revealed; productivity reveals the private signal z_{yt}. Finally, the SOP vote occurs and Board and Shareholder utilities are realized.

Board and Shareholder Beliefs. Both B and S use Bayes' rule to update beliefs about CEO ability after they see signals. I use the subscript a to refer to beliefs shared by B and S , so $\left(\mu_{at}, \sigma^2_{at}\right)$ refers to shared beliefs at the beginning of period t. I use the subscripts b and s when B and S can have different beliefs. In Appendix C.3 (following Taylor, 2010), I show that CEO tenure fully determines the variance of beliefs, so I define the function $\sigma^2_a(\tau)$ to track how the variances of beliefs decreases across the CEO's tenure. That is, given the CEO's tenure τ_t in year t, the variance evolves according to

$$\sigma^2_{at+1} = \sigma^2_a(\tau_t + 1) = \sigma^2_0\left[1 + (\tau_t + 1) \times \sigma^2_0\left(\sigma^{-2}_{z_b} + \sigma^{-2}_{z_s} + \sigma^{-2}_y\right)\right]^{-1}. \tag{10}$$

The mean evolves according to

$$\mu_{at+1} = \sigma^2_a(\tau_t + 1)\left[\frac{\mu_{at}}{\sigma^2_a(\tau_t)} + \frac{z_{bt}}{\sigma^2_{z_b}} + \frac{z_{st}}{\sigma^2_{z_s}} + \frac{z_{yt}}{\sigma^2_y}\right]. \tag{11}$$

The rate of decline of the variance σ^2_{at} means that μ_{at} tends toward the CEO's true ability.

3.3. The Say-On-Pay Vote

Each period, B sets the CEO wage and then S decides whether to fail the SOP. These decisions are informed by each party's private signal, and their beliefs about the other's signal. The game played between the Board and shareholders is the heart of the model, but as the goal is estimation, I aim to keep the game tractable, while also being realistic about the strategies used by Board and shareholders. In this section, I detail S' strategy, holding the Board's wage choice fixed (Section 3.3), then I describe the Board's strategy (Section 3.4).

In Appendix C.4, I detail several assumptions I make about the SOP vote. In line with the reasoning above, each assumption is intended to simplify, while keeping the interaction between the Board and shareholders similar in spirit to what occurs in reality.

3.3.1. The Shareholder's Strategy

Informally, S will fail the SOP if the CEO's wage is "too high" given their beliefs. Fixing the wage choice of the Board, the notion of "too high" will incorporate S' current beliefs about CEO ability and how costly vote failure is to Shareholders. Formally, S sets a threshold posterior belief about CEO ability for which they would be indifferent between the vote failing and passing, which is equivalent to finding the threshold in S' signal distribution that leads to this posterior belief, as such a higher threshold implies a higher probability of SOP failure. Via the Board's expected failure cost, this will lead to lower wages on average, but also raises the expected failure cost for S. S' strategy can be described as choosing the threshold k_{st} that sets a probability (threat) of SOP failure which maximizes S' expected utility,

$$\Pr(\text{SOP fail}_t) = \Pr\big(Z_{syt} \leq k_{st}\big).$$

The signal Z_{syt} incorporates all information that the Shareholder observes at the annual shareholder meeting, and includes both the private signal (z_{st}) and the effect of firm productivity (z_{yt}) on S' beliefs. I assume the threshold S chooses takes the form

$$k_{st} = s_t \times w_t. \tag{12}$$

Fact 1: Pr(SOP fail) is increasing in the wage. Eq. (12) is chosen to match Fact 1, which shows, holding all else constant, a higher CEO wage leads to a higher probability that the SOP vote fails. The threshold is thus increasing in the wage choice of the Board, and the choice variable s_t controls the *sensitivity* of the SOP failure likelihood to changes in the wage. The rest of this section is devoted to describing (i) the distribution that determines SOP failure and (ii) the Shareholder's optimal strategy.

Shareholder's information set when the SOP vote is held. As in Figure 3, at the annual shareholder meeting, output and the wage are revealed to shareholders. S receives two signals about CEO ability: their private signal z_{st} and the productivity signal z_{yt}. S, a Bayesian, considers the weighted average of these signals, with weights determined by the relative precisions. Let $p = \frac{\sigma_{z_s}^{-2}}{\sigma_{z_s}^{-2}+\sigma_y^{-2}}$ be the ratio of the precision of ε_{st} to the precision of both shocks. Hence, *ex ante* the shareholder's signal is distributed according to

$$Z_{syt} = pz_{st} + (1-p)z_{yt} = a + p\varepsilon_{st} + (1-p)\varepsilon_{yt}, \quad Z_{syt} \sim N\left(\mu_{at}, \sigma_{at}^2 + \frac{\sigma_{z_s}^2\sigma_y^2}{\sigma_{z_s}^2 + \sigma_y^2}\right). \tag{13}$$

This is the distribution that matters for the *probability of vote failure*. That is, S incorporates both signals, placing more weight on the signal with better precision. At the time that they commit to their threshold, S has beliefs about CEO ability $\left(\mu_{at}, \sigma_{at}^2\right)$. Given this, the signal Z_{syt} has distribution as in (13). Further, B knows this is the distribution that S' signal will be drawn from; B takes S' beliefs into account when setting the wage.

Fact 1: company performance and SOP outcomes. Eq. (13) is how firm performance affects SOP outcomes in the model. Research has demonstrated that the performance of a company is a critical factor in determining the outcome of SOP voting (Fisch et al., 2018). In the model, if the firm's productivity is high (low), S is unable to distinguish whether it is due to the CEO's expertise or a shock affecting output. A higher z_{yt} (be it due to randomness or true CEO ability) will lower the probability of SOP failure, all else equal.

Distance from the unbiased wage. With no board capture, the profit-maximizing, or *unbiased wage* that the Shareholder would pay is

$$w_t^{\mathrm{U}} = \arg\max_{w_t} \quad E_{st}\left[\exp\left(a + \varepsilon_{yt}\right)\right] w_t^{\alpha} - w_t = \left(\alpha E_{st}[\exp\left(a + \varepsilon_{yt}\right)]\right)^{\frac{1}{1-\alpha}}. \tag{14}$$

The goal of the Shareholder in the model is to get the Board's wage choice as close to the unbiased wage as possible, given the costliness of SOP failure. SOP failure should be determined via *distance* in the observed wage from the unbiased wage. The random variable w_t^{U} is lognormally distributed, with distribution determined by belief tuple $\left(\mu, \sigma^2\right)$ and parameters

$$w_t^{\mathrm{U}} \sim \log N\left(\frac{\mu}{1-\alpha} + C, \frac{\sigma^2}{(1-\alpha)^2}\right), \quad C = \frac{\log\alpha + \frac{1}{2}\sigma_y^2}{1-\alpha}. \tag{15}$$

Thus, given the distribution of Z_{syt} in (13), there is a random variable $w_t^{\mathrm{U}}\left(Z_{syt}\right)$ given by (15) that is the conversion of Z_{syt} to its unbiased wage counterpart.[32] I refer to the CDF of this distribution as CDF_{st}^{U}, where st signifies the Shareholder's period t beliefs about CEO ability.

3.3.2. Determining the probability of SOP failure

Given the previous discussion, it follows that shareholders choose a threshold relative to the unbiased wage they desire. If the unbiased wage associated with the signal realization of Z_{syt} is below the threshold $s_t \times w_t$, the SOP vote will fail.[33] The probability of failure, given w_t is

$$\Pr(\text{SOP fail}_t) = \Pr\left(w_t^{\mathrm{U}}\left(Z_{syt}\right) \leq s_t \times w_t\right) = CDF_{st}^{\mathrm{U}}(s_t \times w_t). \tag{16}$$

Fixing the Board's best response w_t for now, S chooses s_t to maximize expected net operating income, conditional on their beliefs at the start of period t $\left(\mu_{at}, \sigma_{at}^2\right)$. Importantly, S influences expected wages. When setting the vote policy, conditional on the shared belief μ_{at} at the beginning of period t, S takes expectations over signals z_{bt}. At the same time, given

[32]The distribution of $w_t^{\mathrm{U}}\left(Z_{syt}\right)$ is found by plugging μ_{at} and $\sigma_{at}^2 + \frac{\sigma_{z_s}^2\sigma_y^2}{\sigma_{z_s}^2+\sigma_y^2}$ into (15).

[33]Conveniently, the transformation to the lognormal, unbiased wage distribution ensures that S' strategy s_t is just a non-negative, real number, and that the threshold is always increasing in the wage. The wage is guaranteed to be positive (due to lognormal productivity), however CEO ability can be both positive and negative (and hence, draws from the distribution of S beliefs about CEO ability can be both positive and negative.

z_{bt}, B updates beliefs to $\mu_{bt|z_b}$ following standard updating. B then optimally offers $w_t(z_{bt}, s_t)$, which will be detailed in Section 3.4. The Shareholder's problem is

$$\max_{s_t} \int_{z_b} f(z_b) \left[\underbrace{E_{st}[A_t] w_t(z_{bt}, s_t)^{\alpha} - w_t(z_{bt}, s_t)}_{\text{Expected operating income}} - \underbrace{\chi_S \times CDF^{\mathrm{U}}_{st}(s_t \times w_t(z_{bt}, s_t))}_{\text{Expected cost of SOP failure}} \right] dz_b. \tag{17}$$

The Shareholder commits to an *ex ante* threat of vote failure that is increasing in the wage, and the realizations of w_t (or z_{bt}), z_{st} and z_{yt} will determine the outcome of the vote. The Board sees z_{bt} at the compensation committee meeting and sets the wage (see Figure 3). This setup is chosen to reflect the realities of shareholder voting and CEO compensation. The Board has operational interaction with the CEO before deciding the wage. SOPs are influenced by the level of CEO wages and firm performance, so both determine the outcome of the vote.

3.4. The Compensation Committee

Each period, the Board receives their signal about CEO ability z_{bt}, and then decides the CEO's wage. Their beliefs at the beginning of t are $a \sim N(\mu_{at}, \sigma^2_{at})$. Upon receiving z_{bt}, their beliefs become $\left(\mu_{bt|z_b}, \sigma^2_{bt|z_b}\right)$, where

$$\begin{aligned} \mu_{bt|z_b} &= \sigma^2_{bt|z_b} \left(\frac{\mu_{at}}{\sigma^2_{at}} + \frac{z_{bt}}{\sigma^2_{z_b}} \right) \\ \sigma^2_{bt|z_b} &= \left(\sigma^{-2}_{at} + \sigma^{-2}_{z_b} \right)^{-1} = \frac{\sigma^2_{at} \sigma^2_{z_b}}{\sigma^2_{bt} + \sigma^2_{z_b}}, \end{aligned} \tag{18}$$

which is standard Bayesian updating (see Appendix C.3). If B revises its beliefs about CEO ability downwards, they will want to decrease w_t relative to w_{t-1}. To match dynamics in wages, I include the wage adjustment cost from (3) in the Board's problem. In year t, B has beliefs $\left(\mu_{at}, \sigma^2_{at}\right)$ about CEO ability, observes the CEO's previous wage, and chooses compensation for the upcoming fiscal year by solving the following dynamic program

$$\begin{aligned} V(\mu_{at}, \tau_t, w_{t-1}) = \max_{w_t} \quad & E_{bt|zb}[A_t] w_t^{\alpha} - (1-\lambda) w_t - \chi_B \times CDF^{\mathrm{U}}_{st}(s_t \times w_t) - AC(w_t, w_{t-1}; \tau) + \\ & \delta_B \Big[(1 - f(\tau_t)) E_{bt|zb}[V(\mu_{at+1}, \tau_t + 1, w_t)] + f(\tau_t) V^R \Big]. \end{aligned} \tag{19}$$

The state consists of the two variables that track the Board's beliefs about the CEO: the current belief about the mean μ_{at} and the CEO's tenure τ_t, which determines the variance of beliefs σ^2_{at}. The third is the previous period's wage w_{t-1}, which tracks the history of wages paid to the CEO (which is set to zero if $\tau_t - 1 = 0$). Further, to be clear, w_t is a function of both z_{bt} and the shareholder's strategy s_t, however for tractability this notation is omitted from (19). $CDF^{\text{U}}_{st}(s_t \times w_t)$ specifies the probability of SOP failure as detailed in Section 3.3.

Operator $E_{bt|zb}[\cdot]$ is taken with respect to B's beliefs about CEO ability after they receive their signal z_{bt} (so beliefs are distributed according to eq. 18). The Board must calculate the expected productivity of the firm A_t, which is also influenced by the productivity shock ε_{yt}; the likelihood the shareholders will fail the SOP vote; and the expected continuation value. The hazard function $f(\tau_t)$ controls how often the firm separates from the CEO and is an input to the model. Pooling all CEO spells, $f(\tau_t)$ is the frequency of turnover after τ years, conditional on the CEO surviving $\tau - 1$ years.[34] V^R describes the termination value. Upon separating from the CEO, the Board accesses the CEO talent pool and beliefs reset to (μ_0, σ_0)

$$V^R = V(\mu_0, \tau = 0, 0), \tag{20}$$

the value function returns to its starting value (prior beliefs) and there is no previous wage. The Board trades off paying the CEO a biased wage (higher board capture λ) against the probability that the SOP vote fails after S receives their signal z_{st} and output is realized. B also factors in adjustment costs and how today's wage affects their continuation value.

3.4.1. Objective Firm Value

The Board's optimal wage policy admits the model's definition of objective firm value. Given the state and the Board's choice of the wage, firm value is thus

$$V^{\text{OBJ}}\Big(w_t, \mu_{at}, \tau_t, w_{t-1}\Big) = \pi_t - AC(w_t; w_{t-1}, \tau) + \delta_B \times E_{at}\Big[V^{\text{OBJ}}\Big(w_{t+1}, \mu_{at+1}, \tau_t + 1, w_t\Big)\Big], \tag{21}$$

[34] I follow Taylor (2010) in the computation of the hazard rates. For simplicity, $f_0 = 0$ in the estimation, and $f(\tau_t) = 1$, where $\mathbf{T}$ is the cap on the length of CEO tenure. Further, the estimation sample excludes CEO spells that only last the first year.

where $\pi_t = E_{at}[A_t]w_t^{\alpha} - w_t$ is the firm's true operating income given w_t. In contrast to the Board's problem, objective value does not include board capture. In general, the Board's policy w_t will be above the value-maximizing wage. Secondly, firm value does not contain any inputs from the SOP vote, it merely represents the discounted cash flows of the firm. When I undertake counterfactuals, (21) will allow me to analyze how changes to SOP affect firm value (via its effect on the Board's compensation policy).

3.5. Model Solution and Predictions

I use Bayes' rule to derive Board and shareholder beliefs about CEO ability and substitute these beliefs into (19) to obtain the Board's Bellman equation and (17), which is solved numerically. Appendix C.5 provides full derivation of the solution.

I now discuss the model's predictions and, when relevant, provide comparative statics on key model parameters. I focus on the static version of the model. That is, the adjustment cost and continuation value in (19) are dropped and (17) remains the same.

3.5.1. The Shareholder's Strategy

To elucidate how the interaction between shareholders and the Board works, first consider what happens when I vary s, the shareholder's strategy. Figure 4 displays comparative statics of the shareholder's choice of s. Note — this figure is entirely off-equilibrium. For each point, I set S' strategy to $s \geq 0$, and then plot B's best response *as if* the threshold S plays were the equilibrium. Panel A shows the shareholders' maximization problem as a function of the expected threshold set in the SOP vote.[35] On the left y-axis, it shows the Shareholder's maximization problem (the solid blue line). The Shareholder balances the probability of failure (and the likelihood that they face a cost from SOP failure) against bringing the wage closer to the profit-maximizing, unbiased wage. In the same Panel, the right y-axis shows the Board's expected utility (the dashed, orange line). If S' threshold is set to zero, the Board sets the

[35]Specifically, Panel A of Figure 4 shows Expected shareholder utility, as shown in (17), as a function of the *expected* threshold in the SOP vote. In other words, (17) is plotted as a function of

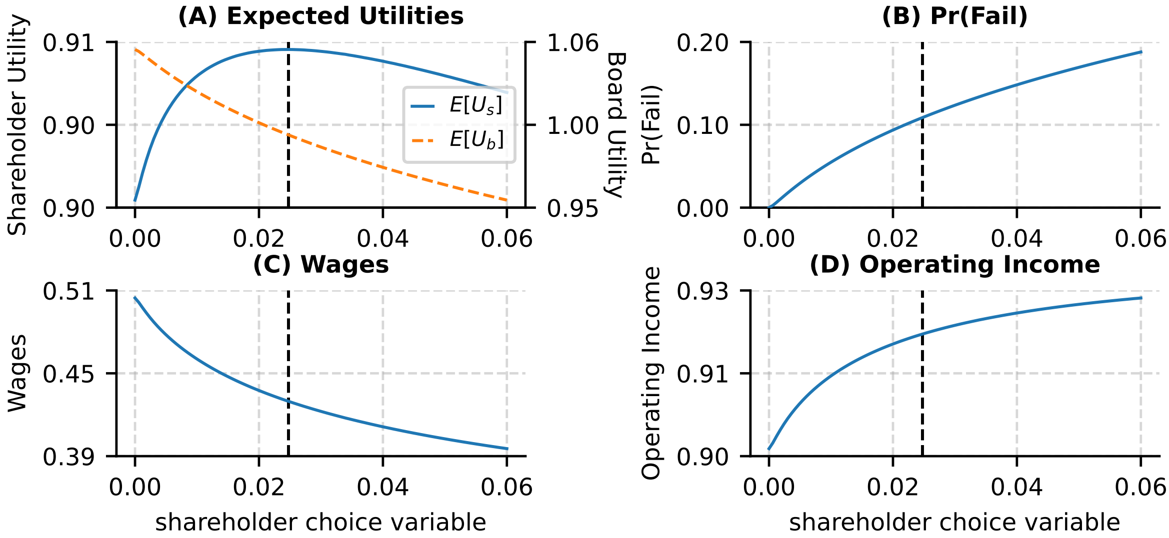
$$E_s[k_s] = s \times E_s[w]$$

where the expectation is taken with respect to shareholder beliefs at the time that they receive their signal.

Figure 4. Comparative statics over Shareholder strategy s

This figure shows how shareholder strategy s influences per-period outcomes, such as Board and shareholder expected utility, expected wage outcomes and the expected probability of failure. To produce the figure, I fix $s \geq 0$ and produce the Board's best response for that s. Each plot shows expected values taken over the Board's signal z_b. For example, Panel A (blue line) displays shareholder utility averaged over the Board's singal z_b, $\int_{zb} f(z_b)\big(E_s[A]w(z_b)^\alpha - w(z_b) - CDF_s^{\mathrm{U}}(s \times w(z_b))\big)dz_b$. The vertical, black and dashed line displays the equilibrium — S' best response.

Parameters:	$\mu_0 = 0$	$\sigma_0 = 1$	$\sigma_y = 1.5$	$\sigma_{z_b} = 2.5$	$\sigma_{z_s} = 3$
	$\chi_B = 0.45$	$\chi_S = 0.1$	$\alpha = 0.25$	$\lambda = 0.3$	$c_w = 0$



biased wage (as if the SOP vote did not exist). As the threshold increases, this comes down with the wage. In other words, shareholders undo the effects of board capture parameter λ.

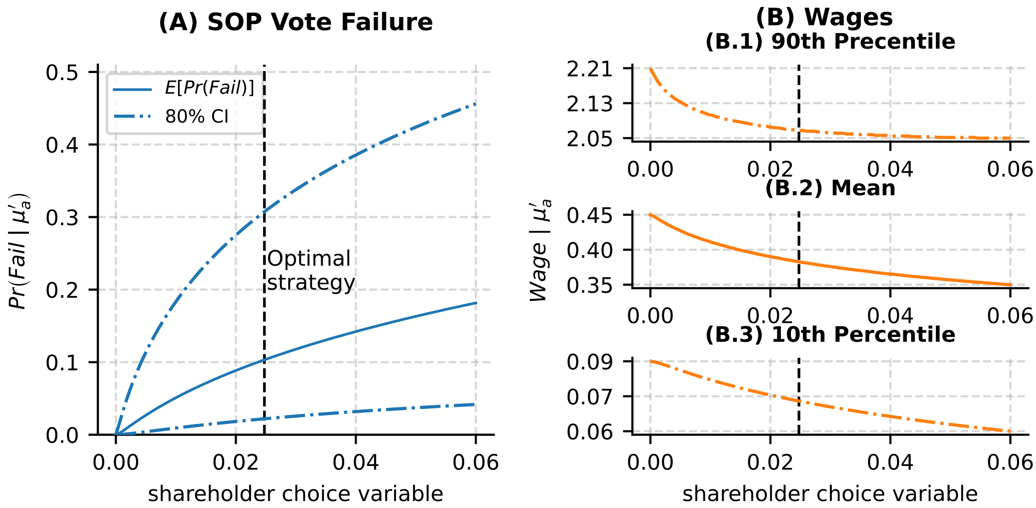
Panel B displays the probability of failure, along with the optimal s from Panel A; the probability of failure is about 10%. Panel C shows expected wages as a function of the threshold. The biased wage is when $s = 0$. S can successfully bring wages down by about 15%. However, they cannot bring wages down to the unbiased level, as net operating income is not maximized, as in Panel D.[36] This panel clarifies the firm-level effect of Shareholder costs to failing SOP on firm value in the model. The utility- profit-maximizing threshold do not align.

Figure 5 displays the uncertainty in SOP vote and wage outcomes in the model. Shareholders can only influence expected wages, hence there is uncertainty based on their threshold choice and the actual outcome of the SOP vote. This uncertainty is caused by divergence in B and S beliefs until the moment the vote occurs. Panel A displays the range of possible outcomes of failure probabilities for a given shareholder choice variables s. The black, dashed line

[36]Note, too high average SOP failure can have a *negative* effect on operating income. If S sets too high a threshold, the Board may bring wages down too far. Further, as the probability of failure tends toward one in all states, the Board will behave as if the threshold does not exist, and wages will tend back toward the biased level.

Figure 5. Shareholder strategy and model outcomes

This figure displays how Pr(SOP fail) and wages are affected by changes in the shareholder's choice variable s across the distribution of the Board's signal z_b. Like in Figure 4, I vary the Shareholder's strategy, and compute B's best response given that strategy. Here, I display how Pr(SOP fail) and wages change at different realizations of z_b. Panel A displays how different realizations of z_b impact Pr(SOP fail). The middle dashed line displays wages if $z_b = \mu_a$, the prior. The top, dashed line displays how Pr(SOP fail) changes if the Board receives a very good signal of CEO ability. Under S' beliefs at the time they commit to their strategy, the Board is overpaying the CEO, hence Pr(SOP fail) is higher. The converse is shown in the lower dashed line, when z_b is at the 10th percentile of the prior distribution. Panel B displays wages given the separate realizations of z_b. Parameters are the same as in Figure 4.



displays the same optimal threshold from Figure 4. The solid blue line displays the expected probability of failure, given Board prior beliefs about CEO ability. The two dashed lines represent the 10th and 90th percentile in outcomes.[37] It shows that the exact value of the threshold is determined by deviation in shareholder and Board beliefs before their signals are revealed. The outcome of the SOP vote itself is random and determined by the threshold $k_s = s \times w(z_b)$ revealed at the end of period. There is thus a layer of uncertainty — the threshold of the vote itself is not determined when shareholders decide their strategy, as S does not see z_b.

Panel B displays the 90th percentile (B.1), mean (B.2) and 10th percentile (B.3) of wage outcomes. When the Board gets a good signal of CEO ability via z_b, they revise upwards their beliefs about CEO ability. From the perspective of the Shareholder, the Board updates "too high," in that it causes a divergence from S' beliefs that drive their choice of threshold (which is held at the prior). The Board further internalizes the higher probability of failure into their wage policy, as wages decrease more sharply when z_b is high *vs.* low (Panels B.1 *vs.* B.3).

[37]In Panel A of Figure 5, given that beliefs are normal, upon receiving signal z_b, the Board will update their beliefs from μ_b to $\mu_{b|z_b}$. As z_b is centered at a, the posterior is equal to the prior. This is displayed in the solid blue line. The two dashed lines display the 10th and 90th percentiles of the posterior normal distribution.

4. Estimation

4.1. Estimation Strategy

I estimate the model's parameters at annual frequency using simulated method of moments (SMM), or indirect inference (McFadden, 1989; Smith, 2016). I use a set of moments that are informative for the parameters, and minimize the distance between the empirical and model-generated moments. The moments arise from an auxiliary model. That is, I estimate a possibly *misspecified* model on the data, and seek to match the moments produced by that model in the simulated data. The auxiliary model must identify model parameters for the estimation to succeed. Most of the details of the estimation are presented in Appendix D.

4.2. Identification Strategy

I make several heuristic arguments to link moments in the data to model parameters. There is a tight link between observed moments in the data and moments produced by the model; nonetheless, I cannot perfectly pin each parameter to its moment in the data. Three key parameters are λ, which describes the degree of board capture; χ_B, which describes how costly SOP failure is for the Board; and χ_S, how costly SOP failure is for Shareholders. Table D.1 displays each moment used in estimation, and the parameter(s) that the moment targets.

Identifying output and CEO skill parameters. I first specify the following functional form for company revenues

$$\log Y_{it} = \underbrace{\log \eta}_{\text{scaling factor}} + \underbrace{a_i + \alpha \log w_{it}}_{\text{CEO component}} + \underbrace{\kappa_1 \log K_{it} + \kappa_2 \log L_{it} + \mu_{IND} + \mu_t}_{\text{non-CEO component}} + \varepsilon_{yit},$$

where i refers to a firm-CEO match, Y_{it} is the revenue generated by the firm, η is a scaling factor, w_{it} is the wage paid to the CEO, a_i is a CEO fixed effect, K_{it} is (PPE), L_{it} is the number of employees, and μ_{IND} and μ_t are industry and time fixed effects. I first residualize revenues by netting out the non-CEO component of revenue. This gives the following form for revenue

$$\log y_{it} = \log \eta + a_i + \alpha \log w_{it} + \varepsilon_{yit} \implies$$

$$y_{it} = \eta A_{it} w_{it}^{\alpha} = \eta \exp\left(a_i + \varepsilon_{yit}\right) w_{it}^{\alpha}. \tag{22}$$

The parameter η is a time-invariant scaling factor which scales operating income to its appropriate level. It can also be thought of as how well the firm is able to translate the CEO's skill and effort into actual revenues, and it allows me to translate how CEO effort and wages ultimately affect revenues. While η is not essential for solving the model, it is important in the estimation as it allows for appropriate comparison across subsamples (Page, 2018). I identify output and CEO skill parameters from the CEO component of company revenues (22). By specifying that revenues are composed of a CEO fixed effect, average CEO skill is not identifiable, the average CEO fixed effect is only pinned down relative to the constant term $\log \eta$. Hence, I normalize average CEO skill to zero, so that $\mu_0 = 0$.

The following (pooled) regression in the data maps exactly to company output in the model

$$\log y_{it} = y_0 + y_1 \log w_{it} + \epsilon_{it}^{y}, \tag{23}$$

where $\log y_{it}$ is the firm's CEO-driven log revenue and $\log w_{it}$ is the CEO's observed log of current compensation. Given $\mu_0 = 0$, $\hat{y}_0$ maps exactly to $\log \eta$, and α is identified via $\hat{y}_1$, the elasticity of firm revenues to the CEO wage, and σ_y via the variance of the residual, $\widehat{Var}\left(\epsilon_{it}^{y}\right)$.

Now, consider average log output over a CEO's tenure from the model less $\alpha \log w_{it}$, which is how the CEO's effort/wage impacts output

$$E_i[\tilde{y}_{it}] = E_i[\log y_{it} - \alpha \log w_{it}] = E_i\left[a_i + \varepsilon_{yit} + \alpha \log w_{it} - \alpha \log w_{it}\right] = E_i[a_i].$$

By taking expectation across each CEO, ε_{yit} drops out because it is mean-zero. I can thus use the variance of the CEO-average of $\tilde{y}_{it}$ to identify σ_0 as

$$Var(E_i[\tilde{y}_{it}]) = \sigma_0^2. \tag{24}$$

That is, I compute the variance of the data-equivalent $\widehat{Var}(E_i[\log y_{it} - \hat{y}_1 \log w_{it}])$.

Parameters that drive the Board's decision. A parsimonious way of describing the optimal wage is that it depends on parameters, the Board's beliefs about the CEO at time t, the probability that SOP vote will fail (given the wage choice), and an adjustment cost if the Board chooses to lower the wage from $t-1$ to t. By conditioning on the previous period's wage and focusing on a one-period version of the model, which allows me to solve for the Board's first-order condition.[38] I can write an approximation to the optimal log wage as

$$\begin{aligned}\log w_{it} \quad \approx \quad & \underbrace{\log(\alpha E_{bt}[A_t])}_{\text{Expected productivity}} \quad - \quad \underbrace{\log(1-\lambda)}_{\text{Board bias}} \\ & \underbrace{-\log\left(1+\frac{\chi_B}{(1-\lambda)} \times pdf^{U}_{sit}(s_{it}\times w_{it})s_{it}\right)}_{\text{Pr(SOP fail)}} \quad + \quad \underbrace{g(w_{it}, w_{it-1})}_{\text{Adjustment cost}},\end{aligned}$$

where $pdf^{U}_{sit}(s_{it}w_{it})$ is the likelihood function of the Shareholder's signal distribution, evaluated at $s_{it}\times w_{it}$ (i.e., it is the likelihood of SOP failure given the Shareholder's optimal strategy and the wage choice). This expression captures the forces that determine the equilibrium wage choice of the Board. The first terms above map to CEO productivity, as CEOs are compensated for how their effort/wage maps to output (higher α) and for the Board's current beliefs about that CEO's productivity (higher expected A_t). The second term captures the Board's bias towards the CEO — higher λ implies that a Board will pay a higher wage, all else equal. The third term captures how the SOP enters into the wage decision. A higher wage will lead to a higher probability of failure, all else equal. The final term captures how adjustment costs enter into the optimal wage choice and create persistence in wage choices across periods.[39]

The regression in the data that maps to this expression is

$$\log w_{it} = b_0 + b_1 \mathbb{1}[\text{SOP fail}_{it}] + b_2 \log w_{it-1} + \epsilon^{b}_{it}. \tag{25}$$

[38]Here, I simplify the Board's problem by fixing w_{it-1} (so the Board is not acting dynamically and takes the adjustment cost as given).

[39]I can write the partial derivative of the adjustment cost with respect to w_t as $AC'(w_t, w_{t-1}) = -2c_w(w_t - w_{t-1})\mathbb{1}[w_t < w_{t-1}]$. Then,

$$g(w_t, w_{t-1}) \approx \log\left(2 + \frac{AC'(w_t, w_{t-1})}{1+\chi_B \times (1-\lambda)^{-1} s_{it} f(s_{it}w_t)}\right).$$

The moment $\hat{b}_0$ maps to productivity and the Board's bias. Expected productivity is determined by the Board's beliefs about the CEO's ability, $\left(\mu_{bt|z_b}, \sigma^2_{bt|z_b}\right)$ after seeing their signal, and output/skill parameters that have already been identified. As b_0 captures the average, individual-Board beliefs are aggregated out, thus $\hat{b}_0$ identifies λ.

The moment $\hat{b}_1$ helps to identify χ_B, because it indicates directly how different wages are in SOP failure relative to SOP pass. Fixing other parameters, if χ_B approaches zero, it must be that b_1 is close to zero — the Board cares little about SOP and will set a similar wage in SOP pass and failure. As χ_B gets larger, a large b_1 must mean that the Board has received a good signal about the CEO (higher expected productivity) in order to deal with higher expected cost of failure. A large $\hat{b}_1$ implies a large χ_B, all else equal.

The Board's wage choice is determined by their signal z_{ibt}. $\widehat{Var}\left(\epsilon^b_{it}\right)$ informs about the precision of the Board's signal. If this quantity is small, this implies that there is little noise in the Board's decision, and vice versa. Lastly, $\hat{b}_2$ corners the dynamic aspect of the Board's problem (persistence in wage across periods) and identifies c_w.

Parameters that drive the Shareholder's decision. In the model, the Shareholder's choice of an *ex ante* probability of SOP failure can be written as a function of beliefs, their private signal z_{sit}, the productivity signal z_{yit}, and the wage w_{it}. In fact, SOP failure can be written closed-form as

$$\mathbb{1}[\text{SOP fail}_{it}] = \mathbb{1}\left[s_{it}w_{it} - w^{\text{U}}_t\left(pz_{sit} + (1-p)z_{yit}\right) \geq 0\right],$$

where $pz_{sit} + (1-p)z_{yit}$ is a linear combination of the two signals z_{sit} and z_{yit}, with weights determined by the volatilities σ_{z_s} and σ_y, transformed to the relevant lognormal distribution given the distribution of S' signal as in (13).[40] The shareholder's choice variable s_{it} controls the sensitivity of SOP failure to the Board's wage choice, hence choices of s_{it} will be greatly influenced by χ_S. At the same time, s_{it} will be influenced by χ_B as S knows the influence on wages is increasing in the impact of the threat of SOP vote failure. The rate of SOP failure will also be increasing in the Board's bias, all else equal, as it will lead to higher wage choices.

[40]The weight is $p = \frac{\sigma^{-2}_{z_s}}{\sigma^{-2}_{z_s}+\sigma^{-2}_y}$, see (13).

Higher productivity (larger z_{yit}) will lead to lower Pr(SOP fail), all else equal, and similarly for better private signals of CEO ability z_{sit}.

The model-implied determination of SOP failure maps to the regression in the data

$$\mathbb{1}[\text{SOP fail}_{it}] = s_0 + s_1 \log w_{it} + s_2 \epsilon^y_{it} + \epsilon^s_{it}, \tag{26}$$

where ϵ^y_{it} is the residual from the output regression (23). It is clear that $\hat{s}_0$ is an informative moment for the two parameters χ_S and λ because $\hat{s}_0$ directly maps to the unconditional SOP failure rate in the data. Higher board capture λ raises wages, which leads to more SOP failures, all else equal. Conversely, higher χ_S will lower the observed rate of SOP failure. The moment $\hat{s}_1$ which describes the sensitivity of (the probability of) SOP failure to the wage, is highly informative about χ_S and χ_B. If χ_B is large, then Shareholders know they can have a larger impact on wages and $\hat{s}_1$ will be larger.

The moment $\hat{s}_2$ conveys how performance affects SOP within the model (Fisch et al., 2018). Note that ϵ^y_{it} informs about not only the productivity shock, but also how CEO productivity across firms (hence it is also influenced by σ_0). As σ_0 and σ_y are identified by other moments, $\hat{s}_2$ helps greatly to identify σ_{z_s}. While the Board's wage choice reveals its private signal, the Shareholder's signal is truly unobservable in the data. Moments $\hat{s}_1$, which describes the sensitivity of SOP failure likelihood to the wage, and $\hat{s}_2$, which describes how performance impacts the SOP failure likelihood, mean the Shareholder's signal is the only unknown remaining. Thus, $\widehat{Var}(\epsilon^s_{it})$ identifies σ_{z_s}.

Bunching in Shareholder votes. The moments so far have identified most model parameters, however the distribution of SOP vote outcomes (relative to the failure threshold) is very informative about χ_B and χ_S. First, I define the data's distance from SOP failure threshold

$$\Delta^{\text{data}} = \text{share against} - \tau, \quad \Delta^{\text{data}} \geq 0 \iff \mathbb{1}[\text{SOP fail}], \tag{27}$$

where τ is the relevant failure threshold (i.e., 30%). This represents distance from the SOP failure threshold (in percentage points). The equivalent object in the model is

$$\Delta^{\text{model}} = CDF^{\text{U}}_{st}(s_t \times w_t) - CDF^{\text{U}}_{st}\left(Z_{syt}\right), \quad \Delta^{\text{model}} \geq 0 \iff \mathbb{1}[\text{SOP fail}], \tag{28}$$

which captures the distance (in percentage points) of the Shareholder's signal from the chosen failure threshold. Note that Δ^{data} and Δ^{model} have fundamentally different distributions. In the data, vote failure is determined via distance from a public, fixed threshold. The model failure threshold is endogenously determined. My identification argument relies on the idea that the conditional distribution of Δ^{data} close to the failure threshold is informative about the relevant conditional distribution of Δ^{model}.

In the model, the Shareholder commits to a single s, thereby committing to a different threshold given different realizations of the Board's signal z_b. While the outcome of the vote is fixed, S commits to a different (weighted) coin-flip given the realization of z_b. Given that s is fixed across z_b, there will be regions of the support of z_s where relatively small changes in w will lead to larger changes in the probability of failure (i.e., when z_s has the highest density, or its PDF has the steepest slope). First, χ_S dictates where each $s \times w(z_b, s)$ will fall in the distribution of S' signal. If χ_S is very high, then $s \to 0$ and bunching as in Figure 2 cannot occur. Similarly if χ_S is very low, then, holding other parameters constant, S will set higher thresholds and push the outcome of the vote to a flatter, less dense portion of the distribution of S' signal; hence bunching is unlikely to occur.

If χ_S is such that realizations of the threshold $s \times w(z_b, s)$ fall in a denser part of the distribution of the shareholder's signal, B can set a similar wage for higher realizations of z_b, if the utility gain from lowering the probability of failure outweighs the loss from not paying the CEO a higher wage. Given a value of χ_S, a higher degree of observed bunching implies a higher χ_B. Put simply, a positive shareholder cost is a necessary condition for bunching to occur, and *how much* bunching occurs helps identify the Board cost.

It is useful to compare the model's notion of bunching and the bunching that occurs in Figure 2. In the data, this type of bunching at least partially driven by large blockholders, that have an idea that they are likely pivotal (as in Pinnington, 2022), swinging the outcome of a vote from a close fail to a close pass. There is no notion of blockholders within the model (there is a single representative Shareholder). However, the *economic* force is the same. In both cases, the blockholder (in the data) and the Shareholder (in the model) must have bad enough beliefs about CEO ability (or the wage paid is too high) in order fail the vote. In both cases, χ_S pushes the failure threshold toward zero — the region where bunching is possible.

The estimation targets a simple, reduced-form measure of bunching (Antill, 2021), which is similar to the estimator used in Figure 2 (Cattaneo et al., 2018), but is easier to implement within the estimation step. Informally, the measure captures how much extra mass is shifted below the failure threshold, relative to a counterfactual density. To start, I bin the data into widths of 0.5% and index each bin by b. I label the bin mid-point as x_b. N_b is the number of SOP vote outcomes that fall in bin b. To estimate a counterfactual density of vote outcomes absent the failure threshold, I first fix a region around the threshold, $\mathcal{E}$, which captures where bunching is most likely to occur

$$\mathcal{E} = \Big\{ b \quad \text{s.t.} \quad x_b \in [-e, e] \Big\},$$

in the estimation I set $e = 2.5\%$. Excluding $\mathcal{E}$, I estimate the predicted bin counts as a polynomial of the bin midpoints,

$$N_b = \sum_{m=0}^{M} \beta_m \left(x_b^m \right)$$

and then predict $\hat{N}_b$ for bins in $\mathcal{E}$. Thus, $\hat{N}_{b|b\in\mathcal{E}}$ represent a counterfactual count for the number of SOP votes that would fall in bin b given there was no bunching in the data. I use these predicted counts to construct the bunching estimator

$$\mathbb{B} = \underbrace{\frac{\sum_{b\in\mathcal{E}} \left(N_b - \hat{N}_b \right) \times \left(\mathbf{1}[x_b < 0] - \mathbf{1}[x_b \geq 0] \right)}{\sum_{b\in\mathcal{E}} \hat{N}_b}}_{\text{Proportion of mass shifted to below threshold}} . \tag{29}$$

$\mathbb{B}$ measures how many SOP votes are shifted from above the failure threshold to below, expressed as a proportion of the sum of the predicted counts. (29) is easily estimable on model-simulated data, so can be used as a targeted moment during the estimation step.

5. Results

Section 5.1 describes the estimation results. I first display the results of the moment-matching exercise, and then the parameters that drive the quality of the model's fit. Section 5.2 provides further analysis on the quality of the fit.

5.1. Estimation Results

5.1.1. Estimated Moments

Table 6 Panel A displays the closeness of model and data moments. The final column displays the t-statistic arising from a two-way t-test between each model and data moment. Overall, the estimated model matches the data moments well. Average log output (moment 1, $\hat{y}_0$), which identifies the scaling factor, is perfectly matched. As η serves only to scale up CEO skill and effort into observed revenues and operating income, it has little impact on other moments and is identified by $\hat{y}_0$.

The elasticity of output to the wage (moment 3, $\hat{y}_1$) slightly under-estimated in the model, but there is no statistically significant difference. This is reassuring as it signals I have identified α.[41] The variance of CEO-average output (moment 2, see eq. 24) is very closely matched, suggesting σ_0 is identified. The output residual variance (moment 4) is very closely matched, suggesting σ_y is identified.

Average log wage (moment 5, $\hat{b}_0$) and the difference in wages when the SOP fails (moment 6, $\hat{b}_1$) are both matched well. That the model can match the observed average wage when the SOP passes and when it fails is reassuring for its fit and identification of the key parameters λ and χ_B. Persistence in log wages (moment 7) is over-estimated in the model, so it is likely that the estimation requires too-high of an adjustment cost c_w to match other moments. The variance of the wage residual (moment 8, $\widehat{Var}\left(\epsilon^b\right)$) is over-estimated in the model. This likely implies that the volatility of the Board's signal σ_{z_b} is too large.

The observed SOP failure rate (moment 9, $\hat{s}_0$) is matched well (7% in the data *vs.* 6.7% estimated). The sensitivity of SOP failure to the wage (moment 10, $\hat{s}_1$) is under-estimated in

[41] While α is estimated to be 0.263, an elasticity of output to the wage greater than results because of variation in CEO skill. More (less) skilled CEOs demand non-linearly larger (smaller) wages and this maps into a larger output-wage elasticity in the model.

the model, but there is no statistically significant difference. That the model can match these key moments closely is reassuring.

The sensitivity of SOP failure to the output residual is very over-estimated in the model (moment 11, $\hat{s}_2$). By incorporating the effect of company performance (by way of it being a signal of CEO ability) into the SOP vote outcome (Fisch et al., 2018), it becomes *too* dependent on the productivity shock. Given the parsimony of the model, it is natural that too much gets shifted towards the productivity signal. In the data, other forces drive SOP so the effect of performance on SOP outcomes, while important, has a smaller magnitude. The model matches the variance of the SOP regression residual (moment 12) closely. Lastly, bunching in shareholder votes (moment 13) is matched closely in magnitude (0.121 *vs.* 0.116 in the estimation), though there is a statistically significant difference between the data and model.

5.1.2. Parameter Estimates

Table 6 Panel B displays the estimated parameters. The estimated board capture parameter is 0.612. I can translate this into how the Board splits the surplus between the Board and shareholders. In Appendix D.6, I show that the split of the surplus the Board wants to pay the CEO can be written as

$$\theta_{\text{CEO}} = \frac{\lambda w_t}{E_t[A_t]w_t^{\alpha} - (1-\lambda)w_t}. \tag{30}$$

When $\lambda = 0$, the Board maximizes profits for shareholders, when $\lambda = 1$, profits are pushed to zero and the CEO captures the entire surplus. Focusing on the CEO of average skill, my estimates suggest that $\theta_{\text{CEO}} = 40.7\%$. This is very similar to Taylor (2013), who estimates that CEOs capture around 50% of surplus on the upside, but bear no downside risk. The degree of board capture I estimate is large, but how much is determined by CEO influence on the Board or outside option is not made explicit in my model. I explore heterogeneity of this parameter by splitting the sample based on a measure of CEO influence on the Board in Section 5.3.1.

The cost of SOP failure to shareholders χ_S is estimated to be 0.088, and the cost to the Board χ_B is 0.240. To interpret these magnitudes, I normalize them by average firm value. I estimate that the Board considers SOP failure to be worth a utility cost equivalent to 2.06%

of unbiased value. For shareholders, this cost is 0.76%, and both of these SOP failure costs are statistically different from zero. Even though the *expected* cost from vote failure is low, the off-equilibrium threat of failing the SOP is very costly to the Board (See Fact 4), which disciplines wages, even in states where SOP failure is very unlikely. Hence, *non-binding SOP votes influence compensation policy.*

It is important to note that these cost parameters are in units of utility, so it is not that SOP failures affect output; the Board and shareholders merely must behave *as if* they do for the model to match observed outcomes. Thus, the shareholder cost to SOP failure makes shareholders pass some SOP votes that would fail if this non-pecuniary cost did not exist. The exact source of the shareholder cost from SOP failure cannot be determined from the estimated model (see Fact 4 for possible sources of this cost).

The mean of CEO skill is normalized to zero (see Section 4.2. The standard deviation of CEO ability needed to match the variance of observed log revenues is 0.542. This implies that the CEO at the 75th percentile of ability is about twice as productive as the CEO at the 25th percentile.[42] These differences imply CEO skill matters.

The standard deviations of the Board's and shareholder's private signals are 1.996 and 0.697 respectively. While the volatility of the innovation in the Board's signal is larger than the Shareholder's, it is important to remember that the Board receives its signal in advance of making their wage choice, and the Shareholder uses their signal to determine the outcome of the SOP vote. Hence, at the point when B and S set their strategies, the Board has more precise beliefs than the Shareholder. The output shock volatility σ_y is 1.043. This implies that a large portion of observed variation in output comes from randomness, rather than CEO skill.

Figure A.7 displays how the variance of (Board and Shareholder) beliefs decline over the CEO's tenure. By the sixth year ($\tau = 5$) of the CEO's tenure, the volatility of beliefs halves. While uncertainty about CEO ability decreases relatively quickly, there is still quite a lot of uncertainty until the median length of the CEO's tenure ($\tau = 7$, as in Table 1).

[42] By CEO skill being normally distributed, the 25th (75th) percentile of productivity is ≈ 0.67 standard deviations below (above) the mean. Hence, the relative productivity of the 75th to 25th percentile CEO is $\approx \exp(1.34 \times \sigma_0)$.

5.1.3. How much does SOP impact CEO pay?

I can use my estimates to test how much SOP disciplines compensation policy. While the magnitude of the Board cost χ_B is informative, the estimation does not directly reveal the true impact of SOP on CEO pay and firm value. Setting $\chi_B = 0$ (while holding other parameters constant), simulating a counterfactual dataset and comparing quantities reveals this impact.

Table 7 displays the results. As this counterfactual is equivalent to removing SOP, I do not display the SOP failure rate. The table also displays the percentage that wages would increase if SOP were removed. It shows that, on average, SOP brings wages down by 4.4%. There is considerable heterogeneity in the impact, at the 25th percentile, there is no change (shareholders would not fail the SOP in the baseline model), and at the 75th percentile, wages are impacted by 8.4%. This is consistent with the evidence from Correa and Lel (2016) who show (in a cross-country analysis) that total CEO pay decreased by 7% upon the adoption of SOP; the similarity in our estimates is reassuring. The table also shows that SOP increases firm value by 4.6% on average. Given the parsimony of the model, this value impact is likely overstated. In sum, this analysis quantifies the answer to the paper's motivating question: non-binding SOP votes do impact compensation policy.

5.2. Model Estimation Validation

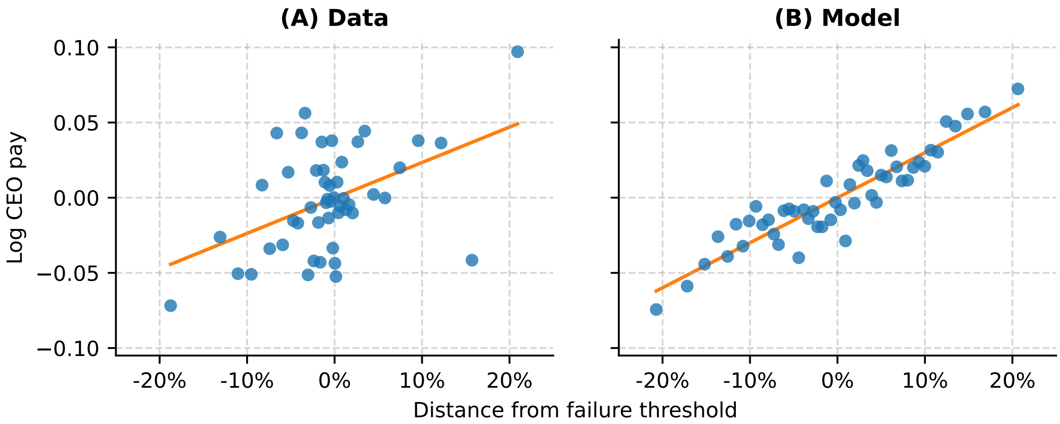
5.2.1. Untargeted Moments

Confidence in the model's implications will be buttressed if there a close relation between untargeted moments in the data.

The relation between CEO pay and SOP vote outcomes. How well does the model match the correlation between CEO pay levels and SOP votes? I test this in Figure 6. I simulate data using the parameters in Table 6. For the real and simulated data, I estimate a regression of current log CEO pay on the outcome of the SOP vote, which is expressed as distance from the failure threshold (see eqs. 27 and 28). I include CEO and CEO tenure fixed effects. The figure shows a striking similarity in the slope relation between CEO pay and the SOP vote outcome in the data and model, though the relation is understandably tighter in the model.

Figure 6. The relation between CEO pay and SOP vote outcomes

This figure displays the relation between the level of CEO pay (log CEO pay) and the outcome of the SOP vote. In both panels, I display a binned scatterplot estimated from a regression of log CEO pay on SOP disapproval, expressed as the vote outcome's distance from the failure threshold. Each regression includes CEO and CEO tenure fixed effects. Panel A is estimated using the real data; For Panel B, I simulate a dataset from the model using the parameters presented in Table 6.



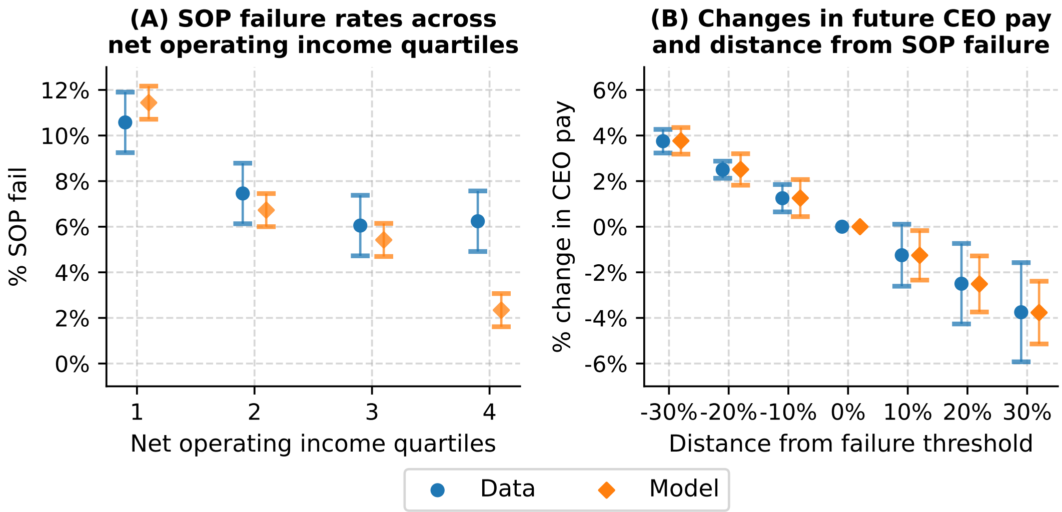
SOP failure across the distribution of operating income. I compare observed SOP failure rates in the simulated and real data along the distribution of net operating income. Importantly, the model targets the unconditional SOP failure rate and how the productivity shock affects SOP results, leaving untargeted how SOP results vary across the operating income distribution. Figure 7 Panel A displays observed SOP failure rates by quartiles of net operating income.[43] The observed model and data SOP failure rates in the first three quartiles of operating income line up very closely. However, the model does a poor job matching the observed failure rate in the top quartile of operating income (2.1% in the model *vs.* 6.1% in the data).[44]

Changes in CEO pay after SOP disapproval. Figure 7 Panel B displays how the model and data compare in terms of *changes* in CEO compensation in response to different SOP disapproval rates. That is, the correlation between the SOP disapproval rate (relative to the failure threshold) and the change in CEO compensation from t to $t + 1$. The panel shows that the slope of this relationship is very similar in the model and data. In the model, the Board is dis-incentivized from lowering CEO wages because of the adjustment cost. However,

[43]In the data, net operating income is the CEO component of revenue less the CEO's wage.

[44]The reason for the higher failure rate in the data in the top quartile of operating income is that CEOs in the top quartile simply receive higher compensation, both in terms of current compensation (salary and bonus) and long-term compensation (stock options); these are the CEOs at the most productive firms and thus they demand higher pay. Shareholders react to the level of CEO pay (see Table 2 Panel A), which can help explain why the model cannot match this moment closely.

Figure 7. SOP failure by firm performance and changes in CEO pay after SOP disapproval
This figure displays two model and estimation validation exercises. I simulate a dataset from the model using the parameters presented in Table 6. Panel A displays observed SOP failure rates across different quartiles of net operating income (industry-adjusted revenue less CEO compensation). Panel B displays estimated changes in CEO compensation in response to how far the previous year's SOP was from the SOP failure threshold. That is, I estimate the regression % Change in Compensation$_{i,c,t,t+1} = \alpha + \beta$Distance from SOP failure$_{i,c,t}$ for firm i, CEO c and year t, and display the predicted change in compensation for different SOP vote outcomes. For both the model and data, I normalize the change in compensation to be 0% at vote failure.



when SOP votes go badly, this means that the shareholders have received a negative signal about CEO ability, either via the productivity shock or their own signal. Hence, high SOP disapproval implies a very *negative* signal about CEO ability. When the disapproval rate in the model is high, the Board realizes that the CEO is likely not a high type, so they pay the adjustment cost and reduce wages.

5.2.2. Is the Shareholder Cost to SOP Failure Necessary?

A key innovation of this paper is presenting evidence of shareholder cost to SOP failure and estimating the precise magnitude of this cost. Despite the survey evidence from Edmans et al. (2021) and the observed bunching in SOP votes below thresholds (Fact 4), direct evidence of the magnitude of the cost comes entirely from the structural model. Identification of parameters in my setting is largely heuristic — the possibility remains that a better minimum exists where the shareholder cost is zero or negligible. I can allay this concern by estimating a version of the model in which I remove the shareholder cost to SOP failure. If the model struggles to approach the key moments in the data *without* this parameter, then at least, the model requires a positive shareholder cost to SOP failure in order to match moments in this setting.

Table A.3 displays the results of the estimation procedure. I estimate the model in Section 3 with $\chi_S = 0$, using the same moments and estimation procedure as the main estimation. Panel A displays the parameters; Panel A displays the estimated moments. This version of the model is rejected by the data. Average wages are too low and in particular, the SOP failure rate (moment 9) is too low — 7% in the data *vs.* 4.6% in the estimation. The estimation further fails to match the bunching estimator (moment 13).

With no shareholder cost, shareholders are willing to fail the SOP in any state. To match the low failure rate, in this alternative specification, the model must push the degree of board capture down towards zero. With $\lambda = 0.092$, this implies a difference in the biased and unbiased wages of only $108 thousand (one sixth of the difference in the main estimation). The Board SOP failure cost χ_B shoots up to 7.15% of firm value (relative to 2.06% in the main estimation). Even with these unbelievable magnitudes, the model cannot match the moments in the data well. Taken together, these findings further imply that the shareholder cost to SOP failure is greater than zero.

5.3. Subsample Analysis

In this section, I re-estimate the model on various subsamples to shed light on how key parameters (namely, board capture and the SOP failure cost parameters) vary in the data. Table 8 displays the results for the analysis. In the table, I present the parameter estimates from each subsample split in tandem, with significance tests between parameters also displayed. Table A.4 displays the parameter estimates (with standard errors) and the model fit for each subsample.

5.3.1. Board co-option

A key result of my estimation is that there needs to be a high degree of board capture for the model to fit the data — my estimates suggest that CEOs should capture 40.7% of the suplus produced by the firm. While the model takes no stance on the channel through board capture arises, Table 3 Panel A shows that *board co-option* (Coles et al., 2014) likely plays a role. Board co-option measures the percentage of the Board that was appointed during the tenure of the CEO; if CEOs influence director selection (Hermalin and Weisbach, 1998) to tilt the compensation committee towards their own utility, then the model should estimate higher board capture for firms with higher board co-option. Importantly, this would confirm that the board capture I estimate is not merely driven by high-CEO bargaining power, and the agency problem SOP is intended to mitigate exists in the data.

I split the sample by the degree of board co-option. To net out the mechanical increasing relationship between co-option and CEO tenure, I regress the degree of board co-option in my sample on CEO tenure fixed effects and save the residuals. As the model requires an entire CEO spell (from first year of tenure to separation), I take the average of the residualized board co-option across a CEO's tenure as my splitting variable. I sort firms into low (high) co-option if they are below (above) median average residualized co-option.

Table 8 columns 1 and 2 display the results of this subsample estimation. The model estimates a much larger degree of board capture in the high board co-option sample (row 1, 0.357 *vs.* 0.632). This means that low co-option CEOs capture 30.5% of the surplus produced by the match and high co-option CEOs capture 51.3%. Importantly, this suggests that the high estimated degree of board capture is not being driven entirely by large CEO outside options.

Interestingly, the Board cost is smaller in the high co-option sample, whereas the shareholder cost is larger (rows 11 and 12). In Table 3 Panel B, I show via reduced-form analysis that board co-option lessens the impact of SOP votes on future compensation policy. My estimates suggest this is driven by the smaller Board cost and larger shareholder cost to SOP failure.

5.3.2. Institutional ownership concentration

Institutional owners, by their size and consequent influence on corporate policies, often take on the role of disciplining management (Kakhbod et al., 2023; Appel et al., 2016; Duan and Jiao, 2016; Brav et al., 2008). In a related paper, Hartzell and Starks (2003) find that institutional ownership *concentration* is negatively related to levels of CEO pay. That is, the presence of large blockholders disciplines compensation policy. However, at the same time, research has shown that the largest blockholders (passive index funds) may be *ineffective monitors* (Heath et al., 2022), in that they tend to vote with management more regularly. My model and estimates can help shed light on this apparent tension.

If large blockholders discipline compensation policy, then the Board's SOP failure cost should be higher for firms with a more concentrated shareholder base. My model also implies that the Shareholder SOP failure cost should increase with blockholder concentration through an *investor focality* channel. When the shareholder base is dispersed, no single investor is focal enough to take the brunt of a failed vote. The focality of the investor corresponds to how likely they are to face the effect of SOP failure. As such, the shareholder cost to SOP failure should increase with blockholder concentration.

I use two measures of blockholder concentration, as inspired by Hartzell and Starks (2003). The first is the percentage of the market capitalization held by the top five institutional investors (top 5 inst. ownership). The second is the HHI of institutional investor base. Columns 1-3 of Table 8 displays the estimated parameters for the sample split into "low" and "high" based on the median average top 5 inst. ownership over the CEO's tenure.[45] Columns 4-6 display the same for the HHI of the institutional shareholder base.

Both measures show that the Board's failure cost is higher when there is more concentration of institutional investors. For example, Columns 1-2, rows 11-12 show that the Board cost is 2.6% (5.6%) of firm value for the low (high) split based on top 5 inst. ownership, and the difference is statistically significant. The Shareholder cost also increases with concentration, going from 0.4% to 2.3% of firm value in the low vs. high sample. Interestingly, for both sample splits in the table, the degree of Board capture is not statistically significantly different, suggesting that this split hones in on how the SOP failure costs vary in the data.

The estimation reveals that large blockholders do discipline compensation policy, as the punishment they can inflict on the Board is larger. However, the cost of *giving* this punishment is also larger. Hence, the largest blockholders (passive funds) are not ineffective monitors *per se*, rather the negative consequences for going against the Board are higher.

6. Counterfactual Analysis

In this section, I present two counterfactual scenarios. First, I present a version in which the Board and Shareholder are allowed to share their information before setting the CEO's wage

[45]To properly estimate the model, sample splits must be done based on the CEO's tenure, the estimation is not feasible if the same CEO spell appears in two sample splits.

and holding the SOP vote. This information-sharing emulates giving a focal shareholder a non-voting, advisory seat on the compensation committee, a governance mechanism often put forth to align the beliefs (and actions) of management and shareholders. In the second, I study the role of the Shareholder cost to SOP failure. Setting the Shareholder cost to zero uncovers how the shareholders' perceived cost to SOP failure limits the impact of SOP.

6.1. Giving a Focal Shareholder an Advisory Board Seat

The degree of board capture I estimate implies there is a conflict of interesting regarding CEO pay between Boards and shareholders. While Say-on-Pay helps to mitigate this distortion, my model and estimates imply that SOP votes are determined to a similar degree by *differences in beliefs* about the CEO. Thus, information-sharing may improve decision-making and enhance the efficacy of SOP.

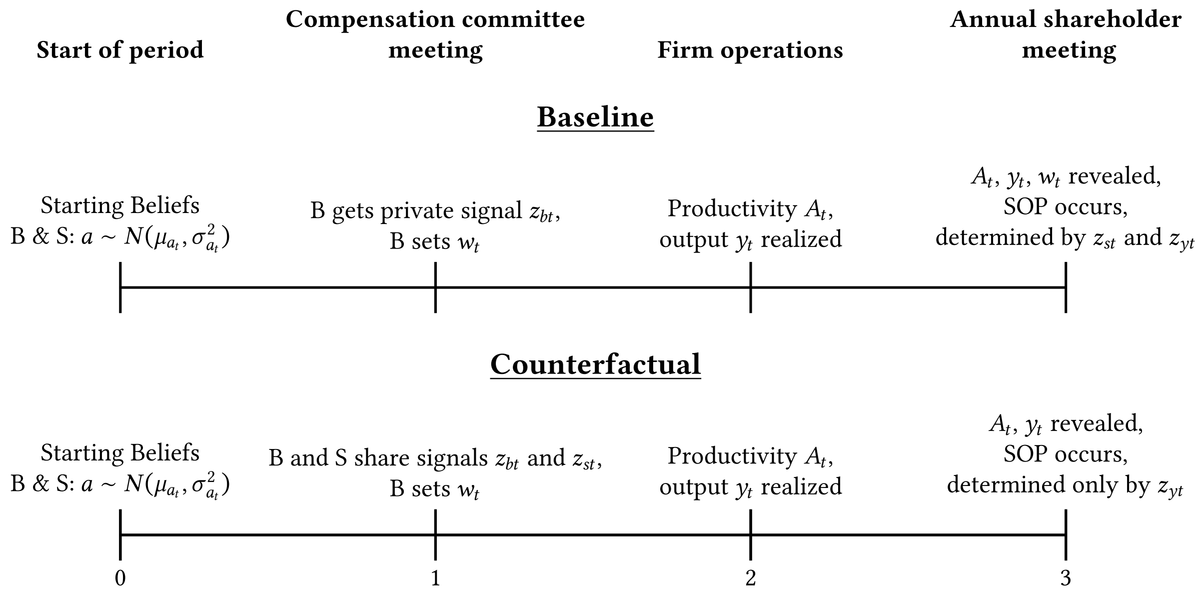
Information-sharing in my model resembles a commonly proffered mechanism to align the beliefs of the corporate decision-maker and investors : giving a focal shareholder a non-voting advisory board seat (Kakhbod et al., 2023). For example, venture capitalists will often take on a "board observer" role, where they attend meetings and share their views, but hold no voting rights. Further, this counterfactual can also be interpreted as giving shareholders an *ex ante* vote on *proposed* compensation policy, as opposed to an *ex post* opportunity to ratify the Board's decision.

It is important to note is that I do not change any underlying parameters in this exercise. As explained below, the structure of my model means that implementing this counterfactual solely involves changing the way information is revealed.

In the baseline model, the Board and Shareholder strategies are determined by their private beliefs, as shown in the top timeline in Figure 8. The baseline inherently implies *belief disagreement*, as B and S signals remain private until the end of the period. By the bottom timeline in Figure 8, in the counterfactual, B and S share their signals in advance of the vote (period 1), so this disagreement is mitigated. Sharing of private signals means the SOP vote is solely a vote on performance *vs.* pay — only the productivity signal influences the vote outcome (period 3).

Figure 8. Sharing of beliefs: Counterfactual model timeline

This figure displays the within-period model timeline of the counterfactual where shareholders have a non-voting position on the compensation committee. The top timeline ("Baseline") displays the timeline from the main version of the model (re-printed from Figure 3), the bottom timeline ("Counterfactual") displays the counterfactual timeline.



It must be mentioned that this counterfactual is not without its flaws. For example, investors state that they prefer not to vote against in SOPs because of the monitoring cost associated with SOP failure (repeated meetings with the compensation committee to discuss future compensation policy, Edmans et al., 2021). Introducing more stringent monitoring (via an observer role on the compensation committee would liekly imply a larger cost.

6.1.1. The Compensation Committee

Like in Section 3.4, each period t the Board meets and receives its signal z_{bt} about CEO ability. However, now the focal Shareholder S shares its signal z_{st} with B. Suppose beliefs at the beginning of t are $a \sim N(\mu_{at}, \sigma^2_{at})$. Let $\mathbf{z}_t = \begin{pmatrix} z_{bt} & z_{st} \end{pmatrix}$, so the shared beliefs upon meeting at the compensation committee are

$$\begin{aligned} \mu_{at|\mathbf{z}_t} &= \sigma^2_{at|\mathbf{z}_t} \left[\frac{\mu_{at}}{\sigma^2_{at}} + \frac{z_{bt}}{\sigma^2_{z_b}} + \frac{z_{st}}{\sigma^2_{z_s}} \right] \\ \sigma^2_{at|\mathbf{z}_t} &= \left[\sigma^{-2}_{at} + \sigma^{-2}_{z_b} + \sigma^{-2}_{z_s} \right]^{-1} \end{aligned} \tag{31}$$

Now, the Board's wage decision is a function of both z_{bt} and z_{st} (i.e., $\mathbf{z}_t$). The Board's dynamic problem is very similar to (19), yet their beliefs are as in (31).[46] Because B and S share their signals, S no longer needs to integrate out B's signal. Hence, they choose s_t to maximize

$$\max_{s_t} \quad E_{at|\mathbf{z}_t}[A_t]w_t(\mathbf{z}_t, s_t)^{\alpha} - w_t(\mathbf{z}_t, s_t) - \chi_S CDF^{\mathrm{U}}_{st}(s_t \times w_t(\mathbf{z}_t, s_t)) \tag{32}$$

The information sharing removes the possibility of private disagreement between B and S — the operator $E_{a_t|\mathbf{z}_t}[\cdot]$ implies that B and S have the same beliefs when they set their strategies.

Two positive effects occur. First, there is a *cooperation effect*. By sharing their beliefs, B and S "meet in the middle," removing the possibility of disagreement over the CEO's skill. Second, there is a *precision effect*, as beliefs mechanically become more precise for both parties. The cooperation effect helps to align compensation policy — B and S arrive at a midpoint in cases when they would have very different beliefs after seeing their signals; it also means that Shareholders can be more directed in when they threaten SOP failure (as they can set a different failure threshold for each realization of the Board's signal). The precision effect means that the Board's wage choice converges faster to a wage appropriate for the CEO's true type, and further removes some uncertainty from the outcome of the SOP vote.

I solve this version of the model using the parameters in Table 6. The counterfactual admits the same outcomes as the main model, so I can compare observed quantities. Table 9 displays the results. I display the counterfactual SOP failure rate, along with the average percentage change in the CEO wage and firm value (see (21) for the model's definition of firm value). The table also displays the distribution (quartiles) of the percentage changes.

The SOP failure rate falls from 6.7% in the main estimation to 5% in the counterfactual. While the change is moderate, this means that shareholders face their perceived cost less often. Wages also fall on average, but this is not a given. When the Board and Shareholder agree that the CEO is good, wages rise (at the 75th percentile, the wage increase is 5%). On

[46] Formally, the Board's Bellman equation is

$$\begin{aligned} V(\mu_{at}, \tau, w_{t-1}) = \quad & \max_{w_t} E_{at|\mathbf{z}_t}[A_t]w_t^{\alpha} - (1-\lambda)w_t - \chi_B CDF^{\mathrm{U}}_{st}(s_t \times w_t) - AC(w_t, w_{t-1}; \tau) + \\ & \delta_B \Big[(1 - f(\tau_t))E_{at|\mathbf{z}_t}[V(\mu_{at+1}, \tau+1, w_t)] + f(\tau_t)V^R\Big] \end{aligned}$$

The only difference to (19) is that the expectations operator follows from (31), as opposed to (18).

average, they fall because of the conflict of interest in my model. The Board's bias leads to sub-optimal (from the shareholders' perspective) over-production, or empire-building. When the Board learns that the Shareholder thinks the CEO is low-type (S gets a bad private signal), this has a relatively stronger effect on decreasing the wage than when the Shareholder thinks the CEO is high-type, which occurs via the curvature of the production function. As such, the 25th percentile change in wages (10.8% decrease) is larger in magnitude than the 75th (5% increase).

Firm value increases on average by 4.9%. Even at the lower end of the distribution, firm value increases considerably (at the 25th percentile, the increase is 3.7%). This is because wages fall on average, so in most cases operating income is brought closer to its profit-maximizing level. Moreover, because of the precision effect, Board beliefs converge faster to the CEO's true ability, avoiding situations when a bad (good) CEO is overpaid (underpaid) early on in their tenure.

All in all, my model predicts that putting a focal shareholder on the compensation committee has positive effects on compensation policy and firm value. However, the structure of the counterfactual implies perfect information-sharing by the Board and Shareholder. It is likely that some information would be lost. The impacts on wages and firm value can be considered an upper bound. This counterfactual further does not consider how costly sitting in on the compensation committee meeting would be for this focal shareholder.

6.2. The Impact of the Shareholder SOP Failure Cost

What if the shareholder cost χ_S did not exist? In other words, if SOP were a truly *costless* governance mechanism, what would be the effect on SOP failure rates, CEO pay and firm value? A caveat applies — removing this shareholder cost represents a *significant* change to the underlying preferences of shareholders. The exercise of changing χ_S while holding other parameters constant is likely not valid. By its nature, SOP is akin to a costly punishment mechanism. In some sense, the cost to shareholders has emerged endogenously as a way validate SOP, even though it is a voice mechanism. By failing the SOP, shareholder *commit* to re-considering the careers of directors (and possibly the CEO); these outcomes incur costs. If SOP were truly costless to shareholders in reality, then the Board would likely view it as "cheap talk."

Nevertheless, Table 10 displays the results. When $\chi_S = 0$, the SOP failure rate increases from about 7% to 42%. The reason the failure rate does not go beyond this can be gleaned from Figure 4; shareholders do not want to decrease below the unbiased wage, and for each state there is a uniquely-defined probability of failure that maximizes Shareholder welfare.

CEO wages would fall by 4.7% on average, and at the 25th percentile wages would decrease by 8.6%. Firm value value increases, but marginally. By enforcing a much higher degree of SOP failure, there are states when shareholders over-discipline the Board. That is, while wages being kept low for bad CEOs is good, it may often be the case that the Board's signal means the CEO is talented and should be paid more. It is worth commenting on the relative value effects in Table 7 (removing the Board cost to SOP failure) and Table 10 (removing the Shareholder cost). The estimation shows that the Board cost is larger: equivalent to 2.06% of value, relative to 0.76% for shareholders. The relative value effect of these two counterfactuals depends on the relative magnitude of these cost parameters.

Summing up, this counterfactual shows that, while the shareholder cost to SOP failure keeps the SOP failure rate low and leads to the Board paying the CEO a higher wage, the impact of removing this cost on value is moderate. SOP is already effective at disciplining the Board — SOP failure is costly enough to the Board to keep wages down. My analysis in Section 6.1 shows that changing the structure of SOP to give shareholders more input into the compensation decision would lower wages (on average) and positively impact firm value. Further, removing this cost is likely too drastic of a change to preferences, and probably renders this counterfactual invalid.

7. Conclusion

This paper establishes if and how shareholders can influence real corporate policies via non-binding, advisory shareholder votes through the lens of the impact of Say-on-Pay (SOP) votes on executive compensation policies. First, I document several key facts about the relation between CEO compensation and SOP vote outcomes. In particular, SOP failure is associated with negative outcomes for compensation committee directors; and shareholders internalize a cost from failing SOP (Edmans et al., 2021).

Second, I posit a model of executive compensation with non-binding SOP votes to explain these observed facts and fit it to several data moments arising from the establishing empirical analysis. The model is able to match these moments closely, and is further validated by similarity in several untargeted moments.

The estimated model reveals that *board capture*, the Board's bias towards paying the CEO too high a wage, is large in the data: CEOs capture 40.7% of the expected surplus, closely in line with Taylor (2013). This bias captures CEO influence on the pay-setting process (Coles et al., 2014) and CEO ability to capture a large share of rents (Gabaix and Landier, 2008). The estimation also reveals how costly SOP failure is to the Board and shareholders. The Board perceives a cost to SOP failure that maps to 2.06% of value; for shareholders it is 0.76% of value. These costs are backed up by empirical patterns and survey evidence.

Even though SOP failure is unconditionally unlikely, the threat of SOP failure disciplines the Board and reveals that non-binding SOP votes impact compensation policy: SOP brings wages down by 4.4% on average. The shareholder cost helps explain the low SOP failure rate. The combination of costs make SOP votes akin to a costly punishment or costly performance evaluation mechanism, in which shareholders can punish the Board, but doing so leads to their own cost.

Lastly, I can use my estimates to construct a counterfactual governance mechanism which gives a focal shareholder a non-binding, advisory position on the Board. This works via the Board and shareholders sharing their private beliefs about CEO ability; and leads to a lower SOP failure rate, decreases wages and increases firm value on average.

This paper stresses that non-binding advisory SOP votes do impact compensation policy. A tangible policy implication from this result is that, if corporate decision-makers internalize a cost to failing environmental or social shareholder proposals, then implementing a mandated, regular vote on these issues similar in spirit to SOP may positively impact shareholder and society welfare, even if these regular "say-on-environment" votes may have a high pass rate.

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Table 1. Summary statistics

This table displays descriptive statistics of the variables used in the empirical analysis and estimating the model. The sample is based upon a merge of Compustat, Execucomp and ISS for the years 2011-2020. I present statistics for the firm, SOP outcomes and the CEO. There are a total of 2,528 CEO spells in the dataset. I limit to CEO spells of greater than one year and at most 25 years.

	N	Mean	Std Dev	25%	50%	75%
Firm						
Assets ($b)	10,001	22.717	128.168	0.879	2.858	9.416
Revenues ($b)	10,001	7.703	21.147	0.596	1.749	5.612
Return on assets (%)	10,001	0.124	0.094	0.070	0.119	0.172
12-month stock return (%)	10,001	0.132	0.323	-0.056	0.113	0.293
Say-on-Pay						
% voting against in SOP	10,001	0.090	0.121	0.023	0.044	0.092
$\mathbb{1}$[Less than 30% support]: **SOP failure**	10,001	0.068				
$\mathbb{1}$[Less than 20% support]	10,001	0.129				
$\mathbb{1}$[Less than 50% support]	10,001	0.018				
CEO						
Salary ($m)	10,001	0.855	0.383	0.600	0.808	1
Bonus ($m)	10,001	0.138	0.640	0	0	0
CEO tenure (years)	10,001	6.502	5.144	2	5	10
Length of CEO tenure (years)	2,528	8.311	5.449	4	7	12

Table 2. SOP results, CEO pay and company performance

This table explores the relation between SOP outcomes and CEO compensation, in support of Fact 1. Panel A estimates the relation between SOP outcomes and the level of CEO pay. The dependent variable in columns 1-4 is an indicator for SOP failure (at least 30% of shareholders voting against the SOP), and in columns 5-8 it is the percentage of shareholders that vote against. Log CEO compensation is the natural logarithm of the CEO's total current pay (salary and bonus). Panel B estimates the relation between changes in CEO compensation (from t to $t + 1$) and SOP results (from t). The dependent variable is the log change in CEO compensation from t to $t + 1$. SOP fail is an indicator if a SOP vote fails, i.e. the % voting against is above 30%. % vote no in SOP is the proportion of shareholders voting to fail the SOP. All covariates are defined in the appendix. Stock return and Return on assets are standardized to mean zero, unit variance. Standard errors are displayed below coefficients and clustered at the firm × CEO level. ***, **, * denote significance at 1%, 5%, 10%.

Panel A. SOP outcomes and the level of CEO wages

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	SOP fail $\{0, 1\}$				% vote no in SOP			
Log CEO compensation	0.015***	0.014***	0.019***	0.032***	0.007***	0.007***	0.010***	0.015***
	(0.004)	(0.003)	(0.006)	(0.011)	(0.002)	(0.002)	(0.003)	(0.005)
Stock return		-0.013***	-0.011***	-0.004		-0.010***	-0.009***	-0.007***
		(0.003)	(0.003)	(0.004)		(0.001)	(0.001)	(0.002)
Return on assets		-0.021***	-0.022***	-0.020**		-0.016***	-0.017***	-0.014***
		(0.006)	(0.007)	(0.008)		(0.003)	(0.003)	(0.004)
Log firm assets		0.039***	0.041***	0.030*		0.018***	0.018***	0.009
		(0.013)	(0.014)	(0.018)		(0.006)	(0.006)	(0.008)
Lagged log CEO compensation				-0.014*				-0.005
				(0.008)				(0.004)
Observations	9,841	9,841	9,556	6,736	9,841	9,841	9,556	6,736
R-squared	0.313	0.322	0.378	0.3c86	0.392	0.410	0.468	0.487
Firm FE	Yes	Yes			Yes	Yes		
Year FE		Yes	Yes	Yes		Yes	Yes	Yes
CEO tenure FE		Yes	Yes	Yes		Yes	Yes	Yes
Firm × CEO FE			Yes	Yes			Yes	Yes

Table 2. Continued
Panel B. Changes in CEO wages and SOP outcomes

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Log change in CEO compensation							
SOP fail {0, 1}	-0.037***	-0.032***	-0.027**	-0.031**				
	(0.012)	(0.012)	(0.011)	(0.014)				
% vote no in SOP					-0.016***	-0.014***	-0.012***	-0.013***
					(0.003)	(0.003)	(0.003)	(0.004)
Stock return		0.006**	0.005*	0.005		0.005*	0.004	0.004
		(0.003)	(0.003)	(0.003)		(0.003)	(0.003)	(0.003)
Return on assets		-0.003	-0.007	-0.006		-0.004	-0.008	-0.007
		(0.005)	(0.005)	(0.005)		(0.005)	(0.005)	(0.005)
Log firm assets		-0.020**	-0.024**	-0.015		-0.020*	-0.024**	-0.015
		(0.010)	(0.011)	(0.012)		(0.010)	(0.011)	(0.012)
Lagged log CEO compensation				-0.039***				-0.039***
				(0.007)				(0.007)
Observations	7,134	7,134	6,845	4,903	7,134	7,134	6,845	4,903
R-squared	0.176	0.193	0.224	0.226	0.179	0.195	0.226	0.228
Firm FE	Yes	Yes			Yes	Yes		
Year FE		Yes	Yes	Yes		Yes	Yes	Yes
CEO tenure FE		Yes	Yes	Yes		Yes	Yes	Yes
Firm × CEO FE			Yes	Yes			Yes	Yes

Table 3. Board capture, CEO compensation and SOP

This table displays how board co-option (Coles et al., 2014), an important empirical measure of *board capture* influences the level of CEO pay and modulates the effect of SOP results on changes in CEO compensation, in support of Fact 2. Panel A presents correlations between the level of CEO pay and the degree of board co-option. Panel B presents similar analysis to Table 2, with an interaction between board co-option and our two measures of SOP disapproval: an indicator for SOP failure (30% or greater vote against in the SOP), and the percent of votes against in the SOP. All covariates are standardized to mean zero, unit variance. Standard errors are displayed below coefficients and clustered at the firm × CEO level. ***, **, * denote significance at 1%, 5%, 10%.

Panel A. Board capture and the level of CEO pay

	(1)	(2)	(3)	(4)
	Log CEO compensation			
Board co-option	0.081***	0.096***	0.095***	0.070***
	(0.029)	(0.024)	(0.024)	(0.023)
Return on assets		0.213***	0.213***	0.135***
		(0.023)	(0.023)	(0.024)
Stock return		0.020*	0.020*	0.036***
		(0.012)	(0.012)	(0.013)
Log firm assets		0.568***	0.577***	0.644***
		(0.023)	(0.030)	(0.033)
Log board size			-0.013	0.018
			(0.024)	(0.023)
Observations	8,865	8,865	8,865	8,865
R-squared	0.023	0.277	0.277	0.333
CEO tenure FE	Yes	Yes	Yes	Yes
Year FE				Yes
Industry FE				Yes

Table 3. Continued

Panel B. Board capture modulates the effect of SOP disapproval on changes in CEO pay

	(1)	(2)	(3)	(4)	(5)	(6)
	Log change in CEO compensation					
Board co-option	0.014	0.010	0.006	0.015	0.016	0.012
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
SOP fail {0, 1}	-0.245***	-0.257***	-0.248***			
	(0.035)	(0.037)	(0.038)			
Board co-option × SOP fail {0, 1}		0.067*	0.063*			
		(0.037)	(0.037)			
% vote no in SOP				-0.078***	-0.081***	-0.079***
				(0.009)	(0.009)	(0.010)
Board co-option × % vote no in SOP					0.019**	0.019**
					(0.009)	(0.009)
Return on assets			-0.037***			-0.041***
			(0.008)			(0.008)
Stock return			0.056***			0.052***
			(0.009)			(0.009)
Log firm assets			-0.013			-0.007
			(0.013)			(0.013)
Log board size			0.002			-0.000
			(0.007)			(0.007)
Observations	6,388	6,388	6,388	6,388	6,388	6,388
R-squared	0.020	0.021	0.034	0.026	0.027	0.039
CEO tenure FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE			Yes			Yes
Industry FE			Yes			Yes

Table 4. Evidence of costs to directors from SOP disapproval

This table displays correlations between costly outcomes for directors and SOP disapproval rates. I focus on directors that serve on the compensation committee during the year of an SOP vote. In Panel A, director turnover occurs when a director is no longer on the Board the year after an SOP vote, conditional on the next year not being the year the director's term ends. In Panel B, Compensation committee turnover occurs when a director is no longer on the compensation committee the year after an SOP vote, conditional on the director remaining as a member of the Board. In Panel C, a reduction in outside Board positions occurs when the number of outside Boards the director sits on decreases in the year after an SOP vote, conditional on the director sitting on at least one outside Board and the director remaining on their current Board the next year (i.e., it is an indicator variable). SOP fail is an indicator if a SOP vote fails, i.e. the % voting against is above 30%. % vote no in SOP is the proportion of shareholders voting to fail the SOP. All covariates are defined in the appendix; all continuous covariates are standardized to mean zero, unit variance. Standard errors are displayed below coefficients and clustered at the director level. ***, **, * denote significance at 1%, 5%, 10%.

Panel A. Director turnover

	(1)	(2)	(3)	(4)	(5)	(6)
	Director turnover {0, 1}					
SOP fail {0, 1}	2.303***	1.755***	1.512***			
	(0.537)	(0.504)	(0.513)			
% vote no in SOP				0.823***	0.673***	0.584***
				(0.176)	(0.168)	(0.173)
Stock return		-0.404**	-0.381**		-0.385**	-0.363**
		(0.174)	(0.173)		(0.174)	(0.174)
Return on assets		-1.460***	-1.625***		-1.443***	-1.603***
		(0.179)	(0.181)		(0.179)	(0.182)
Log firm assets		-0.354**	-1.032***		-0.386**	-1.033***
		(0.179)	(0.202)		(0.179)	(0.201)
Log board size			0.332**			0.342**
			(0.160)			(0.160)
Log director tenure			1.363***			1.364***
			(0.159)			(0.159)
Log director age			2.394***			2.391***
			(0.184)			(0.184)
Log CEO tenure			-1.199***			-1.204***
			(0.163)			(0.163)
Log CEO pay			0.567***			0.521***
			(0.150)			(0.151)
Constant	10.128***			10.418***		
	(0.173)			(0.162)		
Observations	33,213	33,213	33,213	33,213	33,213	33,213
R-squared	0.001	0.174	0.186	0.001	0.174	0.186
Year FE		Yes	Yes		Yes	Yes
Industry FE		Yes	Yes		Yes	Yes

Table 4. Continued

Panel B. Compensation committee turnover, conditional on remaining on Board

	(1)	(2)	(3)	(4)	(5)	(6)
	Compensation committee turnover {0, 1}					
SOP fail {0, 1}	1.462***	1.126**	1.227***			
	(0.449)	(0.452)	(0.459)			
% vote no in SOP				0.640***	0.519***	0.572***
				(0.156)	(0.157)	(0.161)
Stock return		-0.481***	-0.470***		-0.460***	-0.445***
		(0.141)	(0.141)		(0.141)	(0.141)
Return on assets		-0.514***	-0.545***		-0.495***	-0.515***
		(0.148)	(0.152)		(0.148)	(0.152)
Log firm assets		0.097	-0.112		0.071	-0.107
		(0.153)	(0.192)		(0.153)	(0.192)
Log board size			0.326**			0.336**
			(0.140)			(0.140)
Log director tenure			0.193			0.195
			(0.145)			(0.145)
Log director age			-0.234			-0.240
			(0.152)			(0.152)
Log CEO tenure			-0.795***			-0.805***
			(0.140)			(0.140)
Log CEO pay			0.091			0.032
			(0.156)			(0.158)
Constant	5.460***			5.646***		
	(0.144)			(0.137)		
Observations	29,752	29,752	29,752	29,752	29,752	29,752
R-squared	0.000	0.008	0.009	0.001	0.008	0.010
Year FE		Yes	Yes		Yes	Yes
Industry FE		Yes	Yes		Yes	Yes

Table 4. Continued

Panel C. Reduction in outside Board positions, conditional on remaining on Board

	(1)	(2)	(3)	(4)	(5)	(6)
	Reduction in outside board positions {0, 1}					
SOP fail {0, 1}	1.933**	1.879**	1.722**			
	(0.854)	(0.861)	(0.860)			
% vote no in SOP				0.488*	0.463*	0.398
				(0.262)	(0.265)	(0.266)
Log director tenure			-0.187			-0.192
			(0.274)			(0.274)
Log director age			1.935***			1.937***
			(0.290)			(0.290)
Log board size			0.203			0.200
			(0.257)			(0.257)
Outside firm average ROA			-0.126			-0.130
			(0.264)			(0.265)
Constant	9.486***			9.704***		
	(0.293)			(0.282)		
Observations	13,469	13,469	13,469	13,469	13,469	13,469
R-squared	0.000	0.002	0.006	0.000	0.002	0.006
Year FE		Yes	Yes		Yes	Yes
Industry FE		Yes	Yes		Yes	Yes

Table 5. CEO turnover and SOP disapproval

This table analyzes how CEO turnover changes with SOP disapproval. In all specifications, the dependent variable is a CEO turnover indicator in the year following a SOP vote. In columns 1-4, the main independent variable is an indicator for SOP failure, in columns 5-8 it is the percentage of shareholders who vote against the CEO's compensation in the SOP. All controls variables are from the year of the SOP. In columns 5 and 8, I include 5th polynomials of the firm's stock return and return on assets to control for possibly non-linear effects of performance on CEO turnover. Standard errors are displayed below coefficients and clustered at the firm× CEO level. ***, **, * denote significance at 1%, 5%, 10%.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	CEO turnover $t+1$ {0, 1}							
SOP fail {0, 1}	3.169***	3.161***	2.458**	2.327**				
	(1.201)	(1.212)	(1.176)	(1.184)				
% vote no in SOP					1.142***	1.081***	0.806**	0.749*
					(0.377)	(0.382)	(0.383)	(0.386)
Log CEO compensation		-2.550***	-3.279***	29.524		-2.597***	-3.315***	29.119
		(0.629)	(0.684)	(24.560)		(0.631)	(0.689)	(24.553)
Stock return		-1.728***	-1.482***	-1.215		-1.695***	-1.459***	-1.200
		(0.349)	(0.353)	(1.183)		(0.349)	(0.353)	(1.181)
Return on assets		-1.197**	-1.654***	-0.277		-1.150**	-1.618***	-0.242
		(0.505)	(0.557)	(2.622)		(0.506)	(0.558)	(2.620)
Log firm assets		1.034***	1.136	1.168		1.059***	1.131	1.170
		(0.311)	(1.226)	(1.299)		(0.312)	(1.227)	(1.300)
Constant	9.435***				9.752***			
	(0.114)				(0.006)			
Observations	12,378	12,378	12,378	12,378	12,378	12,378	12,378	12,378
R-squared	0.123	0.131	0.214	0.216	0.123	0.131	0.214	0.216
Firm FE			Yes	Yes			Yes	Yes
CEO tenure FE			Yes	Yes			Yes	Yes
Year FE			Yes	Yes			Yes	Yes
Performance Polynomials				Yes				Yes

Table 6. Structural estimation results

This table contains outcomes of the estimation procedure. Panel A displays model and data moments, as well as the difference between each moment. In Panel A, I perform a t-test of the difference in each model and data moment; t-statistics are displayed in the last column. In the last row of the table, I display the result of the χ^2 test of overidentifying restrictions. Panel B displays estimates of the parameters that drive the model in Section 3. As explained in Section 4, μ_0 is normalized to 0, hence this parameter is not estimated. Parameters are estimated using SMM, which is described in detail in Appendix D. The panel also displays the magnitudes of the Board and Shareholder costs to SOP failure as a percentage of the model's average firm value. I compute average firm value in closed form as a function of model parameters, and use the delta method to calculate standard errors (see Appendix D.6 for a derivation).

Panel A. Data and model moments

	Description	**Notation**	**Data**	**Model**	T-stat
(1)	Average log output	y_0	7.540	7.540	0.001
(2)	CEO-average output variance	$Var(E_i[\tilde{y}])$	0.880	0.829	1.000
(3)	Elasticity of output to wage	y_1	0.832	0.797	0.620
(4)	Output residual variance	$Var(\epsilon^y)$	1.278	1.260	0.235
(5)	Average log wage when SOP passes	b_0	-0.140	-0.137	-0.972
(6)	Change in log wage when SOP fails	b_1	0.042	0.055	-0.838
(7)	Log wage persistence	b_2	0.794	0.873	-6.466
(8)	Wage residual variance	$Var\left(\epsilon^b\right)$	0.059	0.077	-5.683
(9)	SOP failure rate	s_0	0.070	0.067	0.674
(10)	SOP failure—wage sensitivity	s_1	0.061	0.038	1.826
(11)	SOP failure—output residual sensitivity	s_2	-0.019	-0.034	2.456
(12)	SOP failure residual variance	$Var(\epsilon^s)$	0.064	0.063	0.164
(13)	Bunching estimator	$\mathbb{B}$	0.121	0.116	3.909
		χ^2 (p-val)	65.296 (0.000)		

Panel B. Parameter estimates

Description	**Notation**	**Value**
Parameters		
CEO board capture	λ	0.612 (0.006)
Board SOP failure cost	χ_B	0.240 (0.007)
Shareholder SOP failure cost	χ_S	0.088 (0.024)
Prior average of CEO ability	μ_0	0
Prior std dev of CEO ability	σ_0	0.542 (0.006)
Output—CEO wage elasticity	α	0.263 (0.011)
Std dev of productivity shock	σ_y	1.043 (0.010)
Std dev of Board signal	σ_{z_b}	1.996 (0.025)
Std dev of Shareholder signal	σ_{z_s}	0.697 (0.014)
Scaling factor	$\log \eta$	7.572 (0.011)
CEO wage adjustment cost	c_w	5.201 (0.373)
Estimated quantities		
CEO surplus capture	θ_{CEO}	40.70% (0.84%)
Board SOP cost (% average value)	$\chi_B \ / \ V_0$	2.06% (0.12%)
Shareholder SOP cost (% average value)	$\chi_S \ / \ V_0$	0.76% (0.23%)

Table 7. The impact of SOP on compensation policy

This table analyzes the impact of SOP on the Board's pay decisions. I simulate a counterfactual in which the Board cost to SOP failure (χ_B) is set to zero while holding other parameters constant, effectively analyzing compensation policy as if SOP did not exist. As SOP no longer enters the model, there is no counterfactual SOP failure rate to display. Rows 2 and 3 display the counterfactual percentage change in wages and firm value when removing the Board cost.

	Mean	**25%**	**50%**	**75%**
SOP failure rate	—			
Percent change in				
Wages	+4.35%	+0.00%	+2.72%	+8.40%
Firm value	-4.58%	-6.22%	-4.47%	-3.40%

Table 8. Subsample heterogeneity

This table contains outcomes of the estimation on the main sample split by different characteristics. Each subsample split is estimated using the same routine as the main sample (see Table 6). Following Section 5.3.1, "Board co-option" measures the percentage of directors appointed during the CEO's tenure, with CEO tenure fixed effects residualized out (as co-option increases mechanically in tenure). Following Section 5.3.2, "Top 5 inst. ownership" calculates the percentage of firm's equity held by the five largest institutional investors and the HHI of the institutional ownership base, both are measures of institutional ownership concentration (Hartzell and Starks, 2003). I take the average of these measures across a CEO's tenure and split the sample into below/above median, so low (high) refers to below (above) the median taken cross-sectionally across CEO spells. I display the parameters from the estimation on each split, along with the t-statistics from a test of equality of the parameters from the split. For example, columns 1 and 2 show the estimated parameters from splitting the sample into above- and below-median Board co-option (Coles et al., 2014), and column 3 displays the t-statistic from testing parameter equality. Columns 1-3 focus on board co-option. Columns 4-6 focus on percentage of equity held by the top five largest institutional investors and columns 7-9 focus on concentration in the institutional shareholder base (as measured by the HHI).

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		Board co-option			**Top 5 inst. ownership**			**HHI inst. ownership**		
	Notation	**Low**	**High**	***t*-stat**	**Low**	**High**	***t*-stat**	**Low**	**High**	***t*-stat**
Parameters										
(1)	λ	0.36	0.63	-25.79	0.54	0.51	0.95	0.59	0.58	0.08
(2)	χ_B	0.41	0.28	5.12	0.40	0.46	-4.16	0.45	0.79	-7.17
(3)	χ_S	0.04	0.18	-1.48	0.07	0.19	-2.43	0.09	0.36	-2.34
(4)	σ_0	0.50	0.36	7.99	0.61	0.43	3.69	0.58	0.62	-2.06
(5)	α	0.43	0.32	8.10	0.28	0.37	-3.80	0.31	0.33	-2.43
(6)	σ_y	1.04	0.92	8.68	1.19	0.94	8.34	1.08	0.93	4.53
(7)	σ_{z_b}	0.73	0.98	-10.90	1.06	0.76	3.17	2.85	0.32	28.49
(8)	σ_{z_s}	1.08	2.22	-7.42	0.64	2.25	-11.39	0.51	3.70	-4.36
(9)	$\log \eta$	7.75	7.76	-0.41	8.08	7.17	21.47	8.31	6.94	32.92
(10)	c_w	4.02	3.23	3.68	5.67	4.12	4.64	5.91	4.65	2.12
Estimated quantities										
(11)	θ_{CEO}	30.5%	51.3%	-9.99	33.6%	41.5%	-4.40	44.0%	45.6%	-0.14
(12)	$\chi_B \,/\, V_0$	4.2%	3.4%	3.83	2.6%	5.6%	-7.00	3.7%	8.0%	-13.06
(13)	$\chi_S \,/\, V_0$	0.4%	2.2%	-1.62	0.4%	2.3%	-2.95	0.7%	3.7%	-3.03

Table 9. Counterfactual exercise: Giving the focal Shareholder an advisory Board position
This table displays a counterfactual experiment where I re-solve a different version of the model, in which the Board and shareholders are allowed to share their signals before the compensation contract is decided (i.e., the shareholder is given a non-voting, advisory seat on the Board). The first row displays the counterfactual SOP failure rate. Rows 2 and 3 display the counterfactual percentage change in wages and firm value. To compute these changes, I re-solve the counterfactual model, applying the same sequence of shocks to each firm. I solve for optimal choices, and solve for the percentage change in each quantity at the observation level. I then display the average percentage change, along with the 25th, 50th and 75th percentiles.

	Mean	**25%**	**50%**	**75%**
SOP failure rate	4.97%			
Percent change in				
Wages	-2.05%	-10.84%	-2.51%	+5.01%
Firm value	+4.87%	+3.68%	+4.19%	+5.07%

Table 10. Counterfactual analysis: Eliminating the Shareholder cost to SOP failure

This table displays two counterfactuals related to changing the Board and Shareholder costs to SOP failure. Following Section 6.1.1, I display the counterfactual in which I change χ_S to 0. The first row displays the counterfactual SOP failure rate. Rows 2 and 3 display the counterfactual percentage change in wages and firm value. To compute these changes, I re-solve the counterfactual model, applying the same sequence of shocks to each firm. I solve for optimal choices, and solve for the percentage change in each quantity at the observation level. I then display the average percentage change, along with the 25th, 50th and 75th percentiles.

	Mean	**25%**	**50%**	**75%**
SOP failure rate	41.68%			
Percent change in				
Wages	-4.74%	-8.64%	-2.97%	0.00%
Firm value	+0.47%	+0.18%	+0.22%	+0.53%

Appendices

A. Appendix Figures and Tables

Figure A.1. Example of monitoring costs arising from SOP failure — 2021 Netflix SOP
This figure presents anecdotal evidence of monitoring costs incurred by shareholders when the SOP fails. The 2021 Netflix SOP saw 49.4% of shares voting against the SOP. Under the 30% failure rule, this presents a clear SOP failure. Netflix directors then repeatedly engaged with large stockholders in the following year over the compensation policy. See Netflix (2022).

Stockholder Engagement and the 2021 Say-on-Pay Vote Result

In 2021, 50.6% of voted shares approved the compensation of our Named Executive Officers. At the time of the vote in 2021, the Compensation Committee had already approved the design of our 2021 executive compensation program. The Compensation Committee reviewed these voting results, and in response, members of the Compensation Committee and management engaged with stockholders to solicit feedback regarding our compensation program.

Figure A.2. Board capture, CEO pay and SOP results: Illustration of Table 3 (Fact 2)

This figure illustrates the results of Table 3. Panel A displays a binned scatterplot of the log of CEO compensation on board co-option (as in Coles et al., 2014). Panel B illustrates the effect of SOP disapproval on changes in CEO compensation for varying levels of board co-option. It uses column 6 of Panel B to estimate the relation between changes in CEO pay and the percentage of shareholders voting against the SOP at different levels of board co-option — going from zero to full board co-option, the regression predicts that the effect of a one standard deviation increase in SOP disapproval on the log change in CEO pay increases from -0.12 to -0.05 log points.

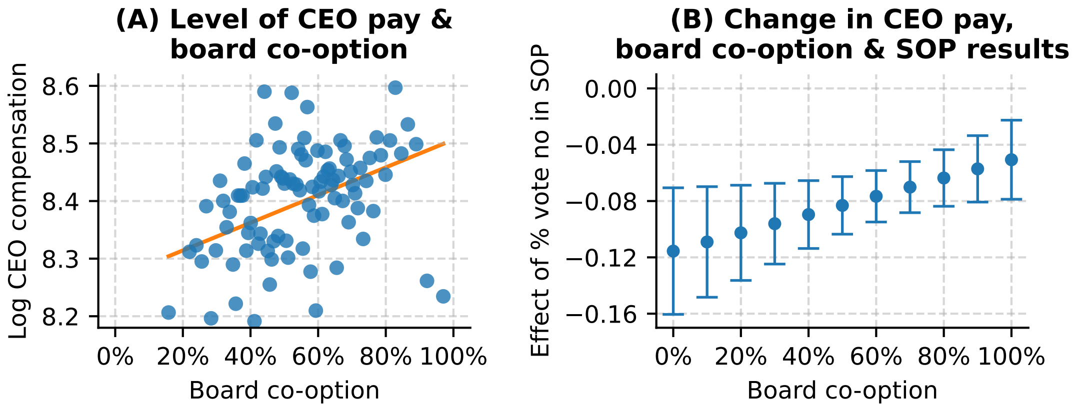

Figure A.3. Placebo test of density manipulation of SOP outcomes (robustness for Figure 2)
This figure displays the results of placebo testing testing for density manipulation of SOP disapproval at placebo thresholds. Whereas in Figure 2, I focus on the publicly accepted important vote failure thresholds of 30% and 50%, in this figure I shift the thresholds to 20% and 40% as a placebo test for density manipulation.

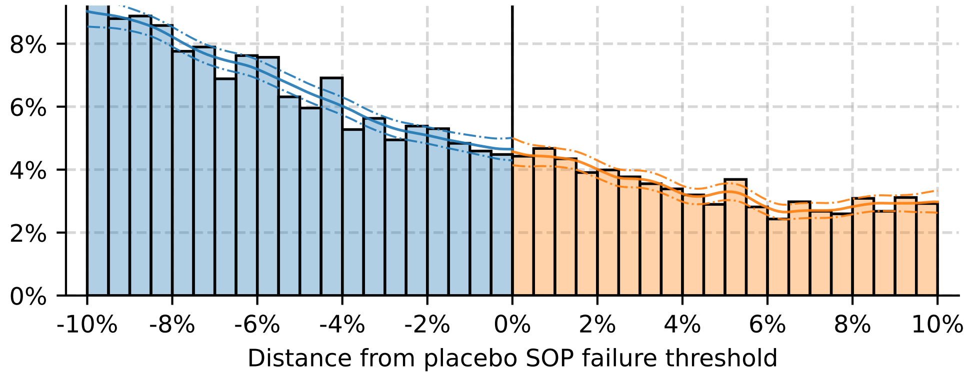

Figure A.4. Correlation between SOP % vote against and firm performance (Fact 1)
This figure displays correlations between SOP disapproval rates and measures of firm performance. Both panels display binned scatterplots. Panel A displays results from a regression of SOP disapproval (% vote against in SOP) on the firm's return on assets (ROA). Panel B displays results from a similar regression, where the independent variable is the firm's 12-month stock return. In both panels, I include year and industry fixed effects, and control for log CEO compensation and CEO tenure.

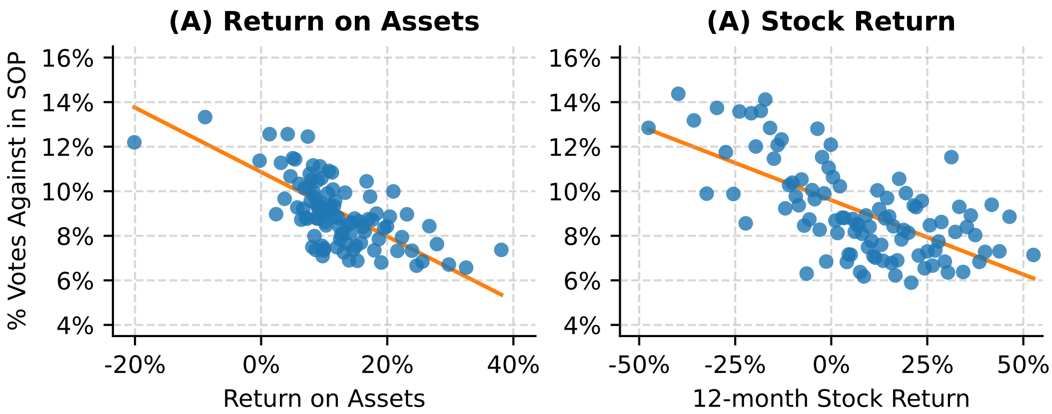

Figure A.5. Histogram of year-on-year changes in CEO compensation

This figure displays histograms of changes in CEO dollar compensation. Panel A displays total compensation (salary+bonus), Panel B displays just salary and Panel C displays bonus. The figure shows that CEO compensation rarely decreases. This reflects the structure of long-term contracts for CEOs, and motivates the inclusion of a one-sided convex adjustment cost on wages in the Board's problem.

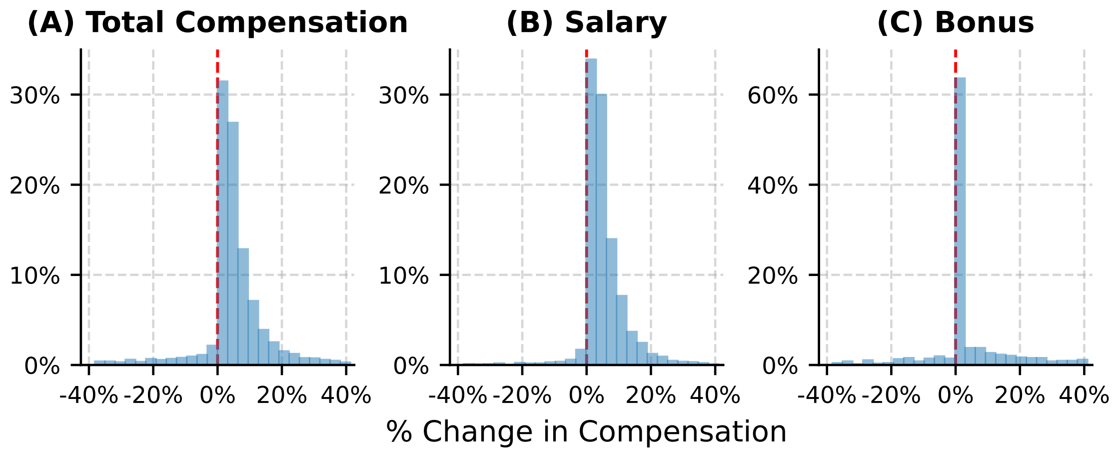

Figure A.6. Model timeline with exact time that strategies are played

This figure displays a more detailed model timeline, with mappings to the relevant assumptions, and when the Board and Shareholder play their strategies. See Figure 3 in the main text for the timeline as it maps to real-world outcomes. See Appendix C.4.

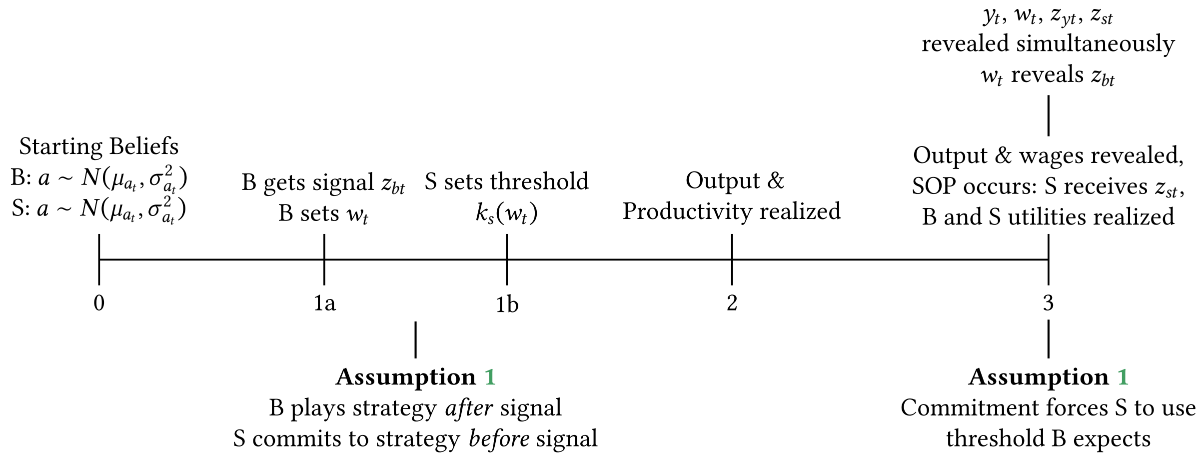

Figure A.7. Rate of decline of the variance of beliefs about CEO ability

This figure displays the rate of decline of the variance Board and shareholder beliefs about CEO ability as a function of CEO tenure τ. The figure uses the parameter estimates from Table 6. Volatility $\sigma_a(\tau)$ is defined in (C.1)

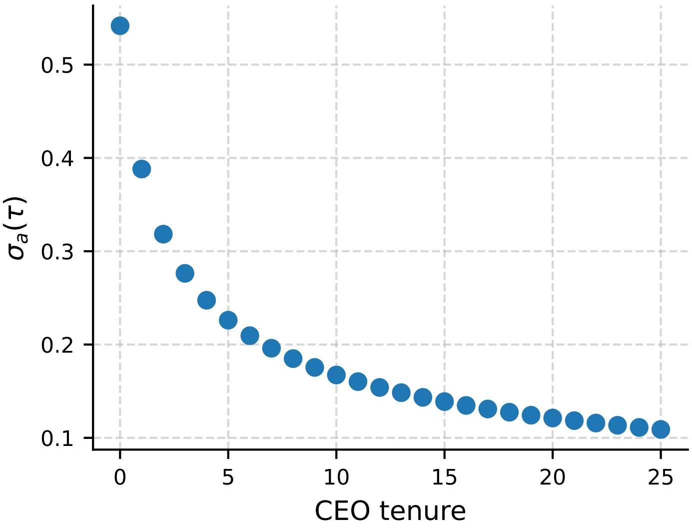

Table A.1. SOP disapproval and company performance

This table displays regressions of SOP vote outcomes (failure and the percentage of shareholders voting against the SOP) on measures of firm performance: the firm's accounting return (return on assets), and the firm's market return (12-month stock return in between SOP votes), in support of Fact 1 and Figure A.4. All covariates are defined in the appendix; all continuous covariates are standardized to mean zero, unit variance. Standard errors are displayed below coefficients and clustered at the director level. ***, **, * denote significance at 1%, 5%, 10%.

	(1)	(2)	(3)	(4)	(5)	(6)
	SOP fail {0, 1}			% vote no in SOP		
Return on assets	-0.027***		-0.024***	-0.020***		-0.018***
	(0.007)		(0.007)	(0.003)		(0.003)
Stock return		-0.016***	-0.014***		-0.012***	-0.011***
		(0.003)	(0.003)		(0.001)	(0.001)
Log firm assets	0.061***			0.030***		
	(0.023)			(0.011)		
Log CEO compensation		0.053***	0.055***		0.027***	0.028***
		(0.009)	(0.010)		(0.005)	(0.006)
Observations	9,864	9,864	9,864	9,864	9,864	9,864
R-squared	0.330	0.329	0.331	0.417	0.417	0.422
CEO tenure FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes

Table A.2. Model parameters

This table displays the parameters of the model, both those to be estimated and those externally calibrated.

Description	**Notation**
Parameters to be estimated	
CEO board capture	λ
Board SOP failure cost	χ_B
Shareholder SOP failure cost	χ_S
Prior average of CEO ability a	μ_0
Prior std dev of CEO ability a	σ_0
Output—CEO wage elasticity	α
Std dev of productivity shock ε_{yt}	σ_y
Std dev of Board signal ε_{bt}	σ_{z_b}
Std dev of Shareholder signal ε_{st}	σ_{z_s}
Scaling factor for estimation	$\log \eta$
CEO wage adjustment cost parameter	c_w
Calibrated parameters	
Board's discount factor	δ_B
Separation probability for CEO of tenure τ	$f(\tau)$

Table A.3. Structural estimation results: No shareholder cost

This table contains outcomes of estimation where I remove the shareholder cost to SOP failure as an estimated parameter. Panel A displays model and data moments, as well as the difference between each moment. t-statistics are displayed in the last column. In the last row of the panel, I display the result of the χ^2 test of overidentifying restrictions. Panel B displays estimates of the nine remaining parameters. Parameters are estimated using SMM, which is described in detail in Appendix D.

Panel A. Data and model moments

	Description	Notation	Data	Model	T-stat
(1)	Average log output	y_0	7.540	7.539	0.117
(2)	CEO-average output variance	$Var(E_i[\tilde{y}])$	0.880	0.895	-0.961
(3)	Elasticity of output to wage	y_1	0.832	0.847	-0.678
(4)	Output residual variance	$Var(\epsilon^y)$	1.278	1.308	-2.006
(5)	Average log wage when SOP passes	b_0	-0.140	-0.149	3.101
(6)	Change in log wage when SOP fails	b_1	0.042	0.057	-0.991
(7)	Log wage persistence	b_2	0.794	0.916	-12.502
(8)	Wage residual variance	$Var\left(\epsilon^b\right)$	0.059	0.074	-5.981
(9)	SOP failure rate	s_0	0.070	0.046	8.106
(10)	SOP failure—wage sensitivity	s_1	0.061	0.062	-0.076
(11)	SOP failure—output residual sensitivity	s_2	-0.019	-0.020	0.347
(12)	SOP failure residual variance	$Var(\epsilon^s)$	0.064	0.052	4.572
(13)	Bunching estimator	$\mathbb{B}$	0.121	0.051	56.535
		χ^2 (p-val)	380.120 (0.000)		

Panel B. Parameter estimates

Description	Notation	Value
Parameters		
CEO board capture	λ	0.092 (0.000)
Board SOP failure cost	χ_B	0.697 (0.001)
Shareholder SOP failure cost	χ_S	—
Prior average of CEO ability	μ_0	0
Prior std dev of CEO ability	σ_0	0.423 (0.000)
Output—CEO wage elasticity	α	0.521 (0.000)
Std dev of productivity shock	σ_y	1.087 (0.001)
Std dev of Board signal	σ_{z_b}	2.430 (0.002)
Std dev of Shareholder signal	σ_{z_s}	0.561 (0.001)
Scaling factor	$\log\eta$	7.612 (0.002)
CEO wage adjustment cost	c_w	3.180 (0.013)
SOP failure costs		
Board SOP cost (% average value)	χ_B / V_0	7.15% (0.01%)
Shareholder SOP cost (% average value)	χ_S / V_0	—

Table A.4. Parameter estimates and model fit for subsample splits
This table displays the parameter estimates with standard errors and model fit for each subsample split presented in Table 8. For brevity, I omit descriptions of parameters and moments from the table.

Panel A.1. Low co-option

Parameters		Moments			
Notation	**Value**	**Notation**	**Data**	**Model**	***t*-stat**
λ	0.357 (0.008)	y_0	7.698	7.698	0.000
χ_B	0.408 (0.026)	y_1	0.939	0.972	-0.818
χ_S	0.041 (0.019)	b_0	-0.141	-0.137	-1.127
μ_0	0.000 (0.000)	b_1	0.044	0.055	-0.445
σ_0	0.500 (0.018)	b_2	0.840	0.860	-1.415
α	0.428 (0.012)	s_0	0.055	0.050	1.207
σ_y	1.045 (0.006)	s_1	0.045	0.036	0.732
σ_{z_b}	0.730 (0.010)	s_2	-0.009	-0.030	4.252
σ_{z_s}	1.075 (0.017)	$Var(E_i[\tilde{y}])$	0.913	0.914	-0.036
$\log\eta$	7.753 (0.018)	$Var(\epsilon^y)$	1.266	1.228	1.493
c_w	4.017 (0.175)	$Var(\epsilon^s)$	0.051	0.057	-1.229
$\chi_B \,/\, V_0$	4.17% (0.18%)	$Var\left(\epsilon^b\right)$	0.049	0.061	-3.265
$\chi_S \,/\, V_0$	0.42% (0.19%)	$\mathbb{B}$	0.046	0.046	-0.160
		χ^2 (p-val)	2.329 (0.507)		

Panel A.2. High co-option

Parameters		Moments			
Notation	**Value**	**Notation**	**Data**	**Model**	***t*-stat**
λ	0.632 (0.007)	y_0	7.729	7.729	0.001
χ_B	0.277 (0.000)	y_1	0.753	0.667	2.577
χ_S	0.178 (0.090)	b_0	-0.110	-0.118	1.708
μ_0	0.000 (0.000)	b_1	0.029	0.052	-1.099
σ_0	0.356 (0.002)	b_2	0.762	0.884	-8.242
α	0.316 (0.007)	s_0	0.080	0.054	5.294
σ_y	0.918 (0.013)	s_1	0.079	0.058	1.607
σ_{z_b}	0.984 (0.021)	s_2	-0.046	-0.032	-2.697
σ_{z_s}	2.223 (0.154)	$Var(E_i[\tilde{y}])$	0.488	0.474	0.524
$\log\eta$	7.763 (0.017)	$Var(\epsilon^y)$	0.967	0.933	1.337
c_w	3.230 (0.123)	$Var(\epsilon^s)$	0.071	0.072	-0.219
$\chi_B \,/\, V_0$	3.39% (0.09%)	$Var\left(\epsilon^b\right)$	0.064	0.049	3.666
$\chi_S \,/\, V_0$	2.18% (1.07%)	$\mathbb{B}$	0.118	0.118	0.251
		χ^2 (p-val)	468.217 (0.000)		

Table A.4. Continued

Panel B.1. Low top five institutional ownership

Parameters		Moments			
Notation	**Value**	**Notation**	**Data**	**Model**	**t-stat**
λ	0.537 (0.004)	y_0	8.071	8.071	0.000
χ_B	0.401 (0.005)	y_1	1.017	1.041	-0.302
χ_S	0.066 (0.026)	b_0	-0.051	-0.046	-1.190
μ_0	0.000 (0.000)	b_1	0.043	0.052	-0.395
σ_0	0.609 (0.047)	b_2	0.818	0.862	-2.683
α	0.278 (0.007)	s_0	0.062	0.072	-1.805
σ_y	1.193 (0.022)	s_1	0.079	0.066	0.706
σ_{z_b}	1.061 (0.080)	s_2	-0.030	-0.032	0.152
σ_{z_s}	0.636 (0.056)	$Var(E_i[\tilde{y}])$	1.061	1.058	0.033
$\log \eta$	8.080 (0.039)	$Var(\epsilon^y)$	1.615	1.618	-0.024
c_w	5.667 (0.312)	$Var(\epsilon^s)$	0.057	0.056	0.018
χ_B / V_0	2.63% (0.20%)	$Var\left(\epsilon^b\right)$	0.048	0.046	0.108
χ_S / V_0	0.43% (0.16%)	$\mathbb{B}$	0.034	0.034	-0.006
		χ^2 (p-val)	1.865 (0.601)		

Panel B.2. High top five institutional ownership

Parameters		Moments			
Notation	**Value**	**Notation**	**Data**	**Model**	**t-stat**
λ	0.514 (0.024)	y_0	7.092	7.092	0.000
χ_B	0.462 (0.014)	y_1	0.767	0.739	0.681
χ_S	0.187 (0.042)	b_0	-0.228	-0.225	-0.669
μ_0	0.000 (0.000)	b_1	0.055	0.073	-0.911
σ_0	0.434 (0.008)	b_2	0.757	0.821	-4.008
α	0.368 (0.022)	s_0	0.078	0.023	12.102
σ_y	0.937 (0.021)	s_1	0.089	0.023	4.335
σ_{z_b}	0.756 (0.053)	s_2	-0.016	-0.016	0.051
σ_{z_s}	2.248 (0.130)	$Var(E_i[\tilde{y}])$	0.780	0.663	5.010
$\log \eta$	7.172 (0.017)	$Var(\epsilon^y)$	0.965	1.004	-1.590
c_w	4.121 (0.116)	$Var(\epsilon^s)$	0.070	0.063	2.035
χ_B / V_0	5.63% (0.38%)	$Var\left(\epsilon^b\right)$	0.054	0.091	-8.386
χ_S / V_0	2.28% (0.61%)	$\mathbb{B}$	0.140	0.139	1.088
		χ^2 (p-val)	36.575 (0.000)		

Table A.4. Continued

Panel C.1. Low blockholder concentration

Parameters		Moments			
Notation	**Value**	**Notation**	**Data**	**Model**	***t*-stat**
λ	0.590 (0.063)	y_0	8.310	8.310	0.000
χ_B	0.446 (0.021)	y_1	0.752	0.816	-0.837
χ_S	0.091 (0.085)	b_0	-0.012	-0.005	-1.377
μ_0	0.000 (0.000)	b_1	0.036	0.056	-0.964
σ_0	0.579 (0.015)	b_2	0.812	0.819	-0.290
α	0.309 (0.007)	s_0	0.069	0.081	-1.793
σ_y	1.078 (0.021)	s_1	0.077	0.042	1.862
σ_{z_b}	2.848 (0.084)	s_2	-0.019	-0.035	0.796
σ_{z_s}	0.512 (0.033)	$Var(E_i[\tilde{y}])$	0.958	0.926	0.391
$\log \eta$	8.307 (0.038)	$Var(\epsilon^y)$	1.401	1.392	0.099
c_w	5.911 (0.125)	$Var(\epsilon^s)$	0.063	0.076	-2.303
$\chi_B \,/\, V_0$	3.69% (0.33%)	$Var\left(\epsilon^b\right)$	0.046	0.086	-1.191
$\chi_S \,/\, V_0$	0.75% (0.74%)	$\mathbb{B}$	0.046	0.045	0.014
		χ^2 (p-val)	6.769 (0.080)		

Panel C.2. High blockholder concentration

Parameters		Moments			
Notation	**Value**	**Notation**	**Data**	**Model**	***t*-stat**
λ	0.582 (0.061)	y_0	6.848	6.848	-0.000
χ_B	0.789 (0.043)	y_1	0.858	0.890	-0.798
χ_S	0.365 (0.081)	b_0	-0.267	-0.279	2.987
μ_0	0.000 (0.000)	b_1	0.062	0.095	-1.521
σ_0	0.618 (0.012)	b_2	0.751	0.605	9.470
α	0.328 (0.005)	s_0	0.071	0.047	5.568
σ_y	0.930 (0.024)	s_1	0.090	0.036	3.648
σ_{z_b}	0.318 (0.029)	s_2	-0.030	-0.029	-0.139
σ_{z_s}	3.698 (0.731)	$Var(E_i[\tilde{y}])$	0.836	0.803	0.856
$\log \eta$	6.935 (0.017)	$Var(\epsilon^y)$	1.183	1.175	0.170
c_w	4.655 (0.579)	$Var(\epsilon^s)$	0.064	0.075	-3.308
$\chi_B \,/\, V_0$	7.99% (0.05%)	$Var\left(\epsilon^b\right)$	0.056	0.067	-2.285
$\chi_S \,/\, V_0$	3.70% (0.64%)	$\mathbb{B}$	0.131	0.120	5.984
		χ^2 (p-val)	42.052 (0.000)		

B. Institutional Details of Say-on-Pay

The 2010 Dodd-Frank Wall Street Reform and Consumer Protection Act, commonly referred to as Dodd-Frank, made SOP compulsory at all US firms from 2011.[1] In the US, SOP is a non-binding vote that must occur at least once every three years on the level and structure of executive compensation. Though SOPs are required only every 3 years, in practice nearly all S&P1500 firms, the main sample, hold the SOP every year; I will commonly refer to SOP being "annual" in the paper, and the model time will be annual. While the vote itself is non-binding, in spirit a low level of shareholder approval for the SOP is likely to lead to tangible changes in the CEO's compensation contract the next year (see Section 2.2 and, e.g., Balsam et al., 2016).

By rule, the SOP vote must cover all executive compensation disclosed pursuant to Item 402 of Regulation S-K. This includes the Compensation Discussion and Analysis (CD&A) section of the proxy statement, which is designed to put into perspective the level of executive pay, its structure (e.g., cash *vs.* stock options) and provide a clear narrative of *why* executives received such pay (Dalton and Dalton, 2008).

A key aspect of SOPs are that they are *backward-looking* and *reactive*. From Novick (2019), "Say-on-pay votes ask shareholders to opine retrospectively on the compensation of named executives that is disclosed in the proxy statement, rather than on the company's compensation program going forward." SOPs in the US are clearly a non-binding confidence vote in the Board's choice of CEO wage for the previous fiscal year, and not a vote in Shareholders' confidence about the next year's compensation contract. This backward-looking aspect will inform the timing of the model. In particular, the practice of the compensation committee setting the wage before and shareholders voting on the wage will play a key role in how the model structures the strategies of the Board and Shareholders.

What constitutes SOP failure? By nature in the US, they are non-binding votes, so there is no threshold at which the compensation committee must make a tangible change. Nevertheless there are three important thresholds for the vote. The most important is 70% support. If support falls below this, Institutional Shareholder Services (ISS) will publicly push the compensation committee and firm more generally to make changes to compensation policy and

[1]Technically, firms with revenue less than $1billion did not have to implement SOP until 2013.

engage with shareholders (ISS, 2022). Further, 80% (the threshold at which Glass-Lewis will pursue the Board) and 50% (the classic simple majority) also represent important thresholds.

Upon SOP failure, the firm's compensation committee will often reach out to the firm's large stockholders with a proposed change to the firm's compensation policy in future years, or simply to discuss how these large shareholders feel about the firm's compensation policy. For example, Figure A.1 displays an example of SOP failure, where the Netflix Board reach out to large shareholders to discuss compensation policy. The model is silent on the repeated nature of this interaction. In the model, there is no retrospective action if SOP fails, rather the Board and shareholders pay the utility cost from failure, and the model moves to the next period. I am not interested in perfectly modeling the game between the Board and shareholders, I merely look to put sensible structure on the data to be able to identify the key parameters driving incentives in this setting.

C. Estimates of the Shareholder Cost Directly Via Bunching

This appendix presents an alternate structural model which uncovers a reduced-form object which maps to a SOP failure cost, in support of Fact 4 in Section 2.2 and the estimates from the structural model presented in Sections 3 and 4. The magnitudes of the SOP failure cost identified via the model in this Appendix are consistent with my main estimates. However, the key issue is that I cannot separately identify the Board and Shareholder costs to SOP failure here; in my main estimation, I use variation coming from endogenous patterns in CEO pay and SOP vote outcomes to separately identify the Board and Shareholder SOP failure costs.

C.1. A simple structural model of costs to SOP failure

Each firm's shareholder base is composed of a group of shareholders, who hold a shareholder approval vote on the Board's pay policy (a SOP vote). The outcome of the vote is $p \in [0, 1]$; $p = 0$ means perfect support for the Board. I abstract away from strategic considerations: the shareholder base coordinate to pick the p that maximizes the utility of the shareholder base.I assume that each p elicits a unique wage and hence each p has a unique effect on firm value, so there is a unique p^* which maximizes firm value. There is an exogenously decided threshold $\underline{p}$, if $p \geq \underline{p}$ then the SOP fails. The shareholders choose p relative to the undistorted maximum p^* to minimize the cost

$$\min_{p} \quad C(p - p^*) + K(p^*) \times \mathbb{1}\left[p \geq \underline{p}\right] \tag{C.1}$$

The first term captures the cost that shareholders incur if the vote choice p is different from the choice p^* that maximizes firm value (the undistorted vote), i.e. the cost incurred from the CEO receiving wage $w(p)$ instead of $w(p^*)$. C has functional form

$$C(p - p^*) = \frac{1}{2}V(p^*)p^*(1 - p \,/\, p^*)^2 \tag{C.2}$$

where $V(p^*)$ is firm value under the undistorted vote. Thus, $C(p - p^*)/V(p^*)$ represents the cost from choosing vote p (when p^* is optimal in the frictionless sense) in percentage terms of firm value. The quadratic cost is standard in the bunching literature (Ewens et al., 2023), and captures in simple form that the cost increases the further the vote outcome is from the undistorted maximum.

The second term of the payoff function is the cost of SOP failure to shareholders, which is paid if p is above $\underline{p}$. K is a constant, and the discrete jump in cost directly at the SOP failure threshold incentivizes bunching directly at $\underline{p}$. There is a marginal vote outcome, $\overline{p}$, for which shareholders are indifferent between between bunching at $\underline{p}$ and issuing vote $\overline{p}$. The indifference of the marginal vote reveals the cost of SOP failure

$$k(\overline{p}) = \frac{K(\overline{p})}{V(\overline{p})} = \frac{C\left(\underline{p} - \overline{p}\right)}{V(\overline{p})} = \frac{1}{2}\overline{p}\left(1 - \underline{p} \,/\, \overline{p}\right)^2 \tag{C.3}$$

Thus, knowing $\overline{p}$ reveals the shareholder cost, relative to firm value, of failing the SOP. To estimate $\overline{p}$, I can use the observed degree of bunching. In the absence of SOP failure cost, the distribution of votes would be smooth around the threshold $\underline{p}$. In the presence of the SOP failure cost, blockholders that fall in $\left[\underline{p}, \overline{p}\right]$ bunch at $\underline{p}$ as the SOP failure cost exceeds the benefit of being at the undistorted maximum. Let f_0 denote the density function of the counterfactual distribution of votes as if there were no SOP failure cost. As Saez (2010); ?); Ewens et al. (2023) point out, the degree of observed bunching is the fraction of agents that fall in $[\underline{p}, \overline{p}]$ under the counterfactual distribution, or

$$\mathbb{B} = \int_{\underline{p}}^{\overline{p}} f_0(x)\, dx = \left(\overline{p} - \underline{p}\right)\overline{f_0}$$

where $\overline{f_0}$ is the average density within the bunching region.[2] Further, bunching can also be written as

$$\mathbb{B} = \int_{p_-}^{p^+} f(x) - f_0(x)\, dx$$

where f is the density function of the observed distribution of votes, and $[p_-, p^+]$ is a narrow region around the threshold $\underline{p}$. The intuition is that this definition of bunching captures the amount of mass that is shifted from $\overline{p}$ to $\underline{p}$, relative to the counterfactual distribution. Note that this definition of bunching is a reduced form object in the data, and we can estimate $\overline{f_0}$ by focusing on the average counterfactual density in $[\underline{p}, p^+]$. Equating the two definitions gives

$$\left(\overline{p} - \underline{p}\right) = \frac{\mathbb{B}}{\overline{f_0}} \tag{C.4}$$

which is a reduced-form object idenfiable in the data (?), and identifies the bunching range, which can be used to estimate the SOP failure cost.

To proceed, I estimate $\widehat{\mathbb{B}}$ as in Section XX, by choosing a region $\mathcal{E}$ close to the threshold, and estimating the counterfactual distribution function as a polynomial of observed counts $\notin \mathcal{E}$. $\widehat{\overline{f_0}}$ is the average density in $\left[\underline{p}, p^+\right]$ from this counterfactual distribution. The ratio of these two objects gives the bunching range, which is used to estimate (??). Table ?? displays the results. In each column, I set a different region $\mathcal{E}$, from $\left[\underline{p} - 1\%, \underline{p} + 1\%\right]$ to $\left[\underline{p} - 3\%, \underline{p} + 3\%\right]$ increasing by 0.5 percentage points in each column. The choices of $\mathcal{E}$ are motivated by Figure2, which shows that this is where the bunching is most apparent. To estimate standard errors, I do 500 bootstrap iterations for each $\mathcal{E}$, and display the error below the estimate. The first row displays the estimated bunching (in percent) for that interval. The degree of bunching ranges

[2]That is, $\overline{f_0} = \left(\overline{p} - \underline{p}\right)^{-1} \int_{\underline{p}}^{\overline{p}} f_0(x)\, dx$.

Table C.1. Estimates of the shareholder cost to SOP failure using bunching

This table displays estimates of bunching in SOP votes, the bunching range that arises from the bunching mass, and the SOP failure cost that arises from the bunching range. In each column, I specify a region around the punching threshold of $\underline{p} = 30\%$, such that $\mathcal{E} = [p_{-}, p^{+}] = \left[\underline{p} - e, \underline{p} + e\right]$, for $e \in \{1\%, 1.5\%, 2\%, 2.5\%, 3\%\}$. In the first column, I display the bunching mass (in percent), as estimated via (29) in Section XX. I use a 5th degree polynomial to estimate the counterfactual distribution. The second row displays the estimated bunching range arising from the bunching mass (eq. ??). The third row displays the estimated SOP failure cost $k(\overline{p})$ (eq. ??). Bootstrapped standard errors, based on 500 replications, clustered by year to account for time trends in SOP votes, are displayed below the estimates. ***, **, * denote significance at 1%, 5%, 10%.

Interval $[p^{-}, p^{+}]$	(1) $\pm 1\%$	(2) $\pm 1.5\%$	(3) $\pm 2\%$	(4) $\pm 2.5\%$	(5) $\pm 3\%$
Bunching $\mathbb{B}$	16.61***	11.18***	10.09***	9.60***	7.72***
	(3.16)	(2.76)	(3.16)	(3.03)	(2.51)
Bunching range $\overline{p} - \underline{p}$	7.13***	7.31***	9.22***	10.81***	10.64***
	(1.35)	(1.74)	(2.75)	(3.27)	(3.29)
SOP failure cost $k(\overline{p})$	0.85***	0.89**	1.42*	1.95**	1.89*
	(0.33)	(0.42)	(0.78)	(0.99)	(0.99)
Observations	3,938	3,938	3,938	3,938	3,938
Bootstrap replications	500	500	500	500	500

from 8% to 17% of observed votes. The second row displays the estimate of the bunching range $\overline{p} - \underline{p}$ (in percentage points). For example, given that $\underline{p} = 30\%$, the first columns shows that the estimated indifference point in the vote is $\overline{p} = 37.13\%$. For each threshold, the degree of bunching and the bunching rage are both statistically significantly different from zero.

The object of interest, the estimated SOP failure cost is displayed in the last row, and ranges from 0.85% to 1.95%. While the magnitude of these costs is identified via the functional form of C, they are entirely consistent with the estimated parameter from my main structural model. However, this simple model cannot disentangle if this is the Shareholder cost or the Board cost. The threshold $\overline{p}$ is a function of the Board's wage best response as much as it is the Blockholder's SOP failure cost.

D. Model Appendix

D.1. CEO Contract and Board Capture Microfoundation

This appendix presents a simple microfoundation of the connection between CEO effort, the CEO wage and output. It also microfounds the Board's bias. In doing so, I show that I cannot separately identify CEO effort aversion from the parameter that governs output's curvature in CEO effort; and the CEO's outside option from the Board's explicitly bias towards overpayment. The CEO is effort-averse and will work for any wage. That is, the Board chooses effort according to the following program

$$\max_{n_t} \quad u(w_t, n_t) = w_t - (n_t)^{\frac{1}{\gamma}}, \quad \gamma \in (0, 1]$$

with $u(w_t, n_t) \geq 0$ (I include the outside option in the Board's problem below). This give $n_t^* = w_t^\gamma$. Output is decreasing returns-to-scale in CEO effort,

$$y_t = A_t(n_t^*)^\beta = A_t w_t^{\gamma\beta}, \quad \beta \in (0, 1)$$

As such, $y_t = A_t w_t^{\gamma\beta}$, and γ and β are not separately identified. I define $\alpha = \gamma\beta \in (0, 1)$ as my main parameter of interest.

In the static model with no adjustment costs and no SOP, the Board solves

$$\max_{w_t} \quad A_t w_t^\alpha - \left(1 - (\overline{u} + \overline{b})\right)^{1-\alpha} \times w_t$$

where $0 \leq \overline{u} + \overline{b} < 1$ represents *board capture*, or the degree to which the Board wants to overpay the CEO relative to the profit-maximizing wage. Formulating the problem in this manner is convenient, as the bias term becomes a constant in logs. The CEO's outside option is $\overline{u}$, and the Board's explicit bias is $\overline{b}$. This term is raised to $1 - \alpha$ so the exponent drops out in the first-order condition. Solving the Board's problem and taking logs reveals that

$$\log w_t^{\mathrm{B}} = \log\left(\frac{1}{1 - \left(\overline{u} + \overline{b}\right)}\right) + \log\left((\alpha A_t)^{\frac{1}{1-\alpha}}\right) = \log\left(\frac{1}{1-\lambda}\right) + \log\left((\alpha A_t)^{\frac{1}{1-\alpha}}\right)$$

As such, $\overline{u}$ and $\overline{b}$ are not separately identified, so I define λ, $0 \leq \lambda \leq 1$ to capture board capture. The Board's bias factor is $\frac{1}{1-\lambda}$ and describes how much more the Board wants to pay the CEO., and in log terms the bias shows up as a constant.

D.2. Microfoundation of Representative Shareholder Assumption

Proposition D.1. *The expected proportion of shareholders voting against the SOP is informationally equivalent to*

$$CDF_s^U(k_s(w))$$

where $CDF_s^U(\cdot)$ is the CDF of the distribution of the random variable which determines the outcome of the SOP vote and $k_s(w) = s \times w$, where w is the CEO's wage and s is the shareholder's choice variable.

Proof. The proof largely follows arguments in Pinnington (2022). In the model, there is a continuum of N_S shareholders, whom each draw a signal z_{si} that is private knowledge, but correlated across shareholders,

$$z_{si} = \overline{z} + \varepsilon_{si}, \quad \varepsilon_{si} \sim N\left(0, \sigma_{si}^2\right).$$

z_i is conditionally normal and independent across shareholders given the common, latent signal $\overline{z}$, distributed according to

$$\overline{z} = a + \varepsilon_{\overline{z}}, \quad \varepsilon_{\overline{z}} \sim N\left(0, \sigma_{\overline{z}}^2\right).$$

The standard voting model with incomplete information assumes that signals are completely private, i.e $z_{it} = a + \varepsilon_{zit}$. With proxy voting, signals are more likely to be correlated. For example, $\overline{z}$ could reflect proxy advisors' recommendations. Note, however, that $\overline{z}$ is not a public signal. Rather, each shareholder shares the same belief about $\overline{z}$. So, it is as if shareholders each receive the proxy advisor's signal with some "noise," which could reflect, e.g. idiosyncratic trust in the proxy advisor across shareholders.

Shareholders play a symmetric cutoff strategy, voting against the proposal if and only if they draw a signal below their cutoff value

$$\mathbb{1}[\text{SOP fail}_i] \iff z_i \leq k_s^i(w).$$

Note — I have abstracted away from the effect of the output shock on the vote, and adjudging failure using lognormals. Given that the output shock is common knowledge, it will affect all shareholers voting in the same way, so does not impact the proof; the conversion to lognormal is a technical assumption that again affects all shareholders equivalently.

Given $\overline{z}$, the probability that a single shareholder votes against is

$$\Pr(\text{SOP fail}_i \mid \overline{z}) = \Phi\left(\frac{k_s^i(w) - \overline{z}}{\sigma_{si}}\right)$$

and the probability I observe N out of N_S shareholders voting against is

$$Pr(N \mid \overline{z}) = C_N^{N_S}\left[\Phi\left(\frac{k_s^i(w) - \overline{z}}{\sigma_{si}}\right)\right]^N\left[1 - \Phi\left(\frac{k_s^i(w) - \overline{z}}{\sigma_{si}}\right)\right]^{N_S - N}.$$

Fixing the unknown type a, I can find the probability of observing N out of N_S against votes,

$$Pr(N \mid a) = \int f(\overline{z} \mid a) Pr(N \mid \overline{z})\, d\overline{z}.$$

Let p be the proportion of shareholders voting against: $p = N/N_S$. Since p is Binomial, as $N_S \to \infty$, the distribution of p becomes increasingly peaked around its mean. Since its mean is the probability any individual shareholder votes against the proposal, the likelihood of observing p vanishes in the limit when $Pr(SOP_i = 1 \mid \overline{z})$ is anything other than p. Given that $\overline{z}$ completely determines $Pr(SOP_i = 1 \mid \overline{z})$, there is a bijection between $\overline{z}$ and p

$$\overline{z}(p) = k_s(w) - \sigma_{si}\Phi^{-1}(p)$$

Using this peakedness, the limit of the density of observing p as $N_S \to \infty$ is

$$f(p) = \int f(a) f(\overline{z}(p) \mid a)\overline{z}'(p)\, da$$

The likelihood of observing p is driven by the likelihood of observing $\overline{z}(p)$, scaled by a change-of-variable term $\overline{z}'(p)$. Since $\overline{z}$ is conditionally normal around the type a, I integrate over all types a and then take the likelihood of observing $\overline{z}(p)$ given the type a. I am more interested in $f(a \mid p)$ — the density of a conditional on observing p,

$$\lim_{N_S \to \infty} f(a \mid p) = \frac{\lim_{N_S \to \infty} f(a) f(p \mid a)}{\int \lim_{N_S \to \infty} f(a) f(p \mid a)\, da}.$$

The intuition is that the posterior likelihood of a is proportional to two components: the prior $f(a)$; and the likelihood that the latent signal $\bar{z}$, given a, is equal to $\bar{z}(p)$, which in the limit is the only $\bar{z}$ for which I would see p. This is a scaled product of Gaussians, so the posterior is also normal,

$$a \mid p \sim N(\mu_{ap}, \sigma^2_{ap}),$$

where

$$\mu_{ap} = \frac{\sigma^2_{\bar{z}}}{\sigma^2_a + \sigma^2_{\bar{z}}} \mu_a + \frac{\sigma^2_a}{\sigma^2_a + \sigma^2_{\bar{z}}} \bar{z}(p), \qquad \sigma^2_{ap} = \frac{\sigma^2_a \sigma^2_{\bar{z}}}{\sigma^2_a + \sigma^2_{\bar{z}}}.$$

Thus, observing p is informationally equivalent to observing a signal $z_s = \bar{z}(p) = k_s(w) - \sigma_z \Phi^{-1}(p)$, where $z_s = a + \varepsilon_s$, and $\varepsilon_s \sim N(0, \sigma^2_{z_s})$.

The proof arises because of the assumptions about the correlated signal and the continuum of shareholders. All shareholders play a symmetric cutoff strategy; in the limit, the exact proportion of shareholders that receive a signal below the cutoff *must* be equivalent to the probability that an informationally equivalent aggregate signal falls below the cutoff. Another way to think about this is to consider a representative shareholder that interacts with the Board, and aggregates the votes or signals of the shareholder base at the shareholder meeting.

■

D.3. Evolution of Board and Shareholder Beliefs

I first detail two Propositions, which define how beliefs update in the model. Then I define exactly how Board and shareholder beliefs change within each period.

D.3.1. Evolution of Beliefs Period to Period

Prop. C.2 shows how beliefs change from t to $t+1$. Prop. C.3 describes the distribution of next period beliefs given today's beliefs, which is used when the Board calculates their (expected) continuation value.

Proposition D.2. *From period t to $t+1$, the variance of beliefs for both the Board and shareholders declines deterministically according to*

$$\sigma_a^2(\tau+1) = \left[\sigma_a^{-2}(\tau) + \sigma_{z_b}^{-2} + \sigma_{z_s}^{-2} + \sigma_y^{-2}\right]^{-1} \tag{D.1}$$

where τ is the tenure of the CEO at year t. Equivalently, I can write the variance of beliefs about CEO ability entirely as a function of CEO tenure τ and model parameters

$$\sigma_a^2(\tau) = \sigma_0^2\left[1 + \tau\left(\kappa_{z_b}^{-1} + \kappa_{z_s}^{-1} + \kappa_y^{-1}\right)\right]^{-1} \tag{D.2}$$

where $\kappa_{z_b} = \sigma_{z_b}^2/\sigma_0^2$, $\kappa_{z_s} = \sigma_{z_s}^2/\sigma_0^2$ and $\kappa_y = \sigma_y^2/\sigma_0^2$

Similarly, from period t to $t+1$, the mean of beliefs for both the Board and shareholders evolves according to

$$\mu_{at+1} = \sigma_a^2(\tau+1)\left[\frac{\mu_{at}}{\sigma_a^2(\tau)} + \frac{z_{bt}}{\sigma_{z_b}^2} + \frac{z_{st}}{\sigma_{z_s}^2} + \frac{z_{yt}}{\sigma_y^2}\right] \tag{D.3}$$

Proof. The formulas are standard results in Bayesian learning (e.g., Pastor and Veronesi, 2009; Taylor, 2010).[3] The Board and shareholder reveal their signals each period. Thus, Board and shareholders share the same beliefs about the variance from period to period. ■

Proposition D.3. *The mean and variance of the mean of $t+1$ CEO beliefs at t are*

$$\begin{aligned} E_t[\mu_{at+1}] &= \mu_{at} \\ Var_t[\mu_{at+1}] &= \sigma_a^2(\tau) - \sigma_a^2(\tau+1) \end{aligned} \tag{D.4}$$

That is,

$$\mu_{at+1} \mid \mu_{at}, \tau \sim N\left(\mu_{at}, \sigma_a^2(\tau) - \sigma_a^2(\tau+1)\right)$$

Proof. I drop time subscripts for convenience, and use $\cdot'$ to denote next period. Via Prop. C.2, the mean evolves as

$$\mu_{a'} = \sigma_{a'}^2\left[\frac{\mu_a}{\sigma_a^2} + \frac{z_b}{\sigma_{z_b}^2} + \frac{z_s}{\sigma_{z_s}^2} + \frac{z_y}{\sigma_y^2}\right]$$

[3] See also the internet appendix for Taylor (2010).

where $z_y = \ln A = a + \varepsilon_y$ is the productivity signal. Let $p' = \sigma_{a'}^{-2}$, i.e the next period precision of beliefs. Let p_a, p_b, p_s, p_y be precisions $\sigma_a^{-2}, \sigma_{z_b}^{-2}, \sigma_{z_s}^{-2}, \sigma_y^{-2}$ respectively. Then define $\rho_{X \in \{a,b,s,y\}}$ be each precision divided by p', e.g. $\rho_a = \frac{p_a}{p'}$. I can write,

$$E[\mu_{a'} \mid \mu_a] = \big(\rho_a + \rho_b + \rho_s + \rho_y\big)\mu_a = \mu_a$$

which of course must hold because beliefs are a martingale. I can write $Var(\mu_{a'} \mid \mu_a)$ as

$$\begin{aligned} Var(\mu_{a'} \mid \mu_a) &= E\Big[\big(\rho_a\mu_a + \rho_b z_b + \rho_s z_s + \rho_y z_y - E[\mu_{a'} \mid \mu_a]\big)^2 \mid \mu_a\Big] \\ &= E\Big[\big(\rho_a(\mu_a - \mu_a) + \rho_b(z_b - \mu_a) + \rho_s(z_s - \mu_a) + \rho_y\big(z_y - \mu_a\big)\big)^2 \mid \mu_a\Big] \\ &= E\Big[\big(\rho_b(z_b - \mu_a) + \rho_s(z_s - \mu_a) + \rho_y\big(z_y - \mu_a\big)\big)^2 \mid \mu_a\Big] \end{aligned}$$

Note that $E\big[(z_b - \mu_a)^2 \mid \mu_a\big] = \sigma_a^2 + \sigma_{z_b}^2$, which similarly holds for subscript s and y. Hence, I can write $Var(\mu_{a'} \mid \mu_a)$ as

$$Var(\mu_{a'} \mid \mu_a) = \sigma_a^2\big(\rho_b + \rho_s + \rho_y\big)^2 + \rho_b^2\sigma_{z_b}^2 + \rho_s\sigma_{z_s}^2 + \rho_y\sigma_y^2$$

Note that $\rho_b^2\sigma_{z_b}^2 = \frac{\rho_b}{p'}$, similarly for s and y, and $1 = \rho_a + \rho_b + \rho_s + \rho_y$, so I can again write

$$Var(\mu_{a'} \mid \mu_a) = \sigma_a^2(1 - \rho_a)^2 + \frac{1 - \rho_a}{p'}$$

Lastly, I note that $\sigma_a^2(1 - \rho_a) = \sigma_a^2 - \frac{\sigma_a^2 p_a}{p'} = \sigma_a^2 - \sigma_{a'}^2$, and

$$\begin{aligned} Var(\mu_{a'} \mid \mu_a) &= (\sigma_a^2 - \sigma_{a'}^2)(1 - \rho_a) + \sigma_{a'}^2(1 - \rho_a) \\ &= \sigma_a^2(1 - \rho_a) \\ &= \sigma_a^2 - \sigma_{a'}^2 \end{aligned}$$

and I am done. Equivalently, I can write this as $\frac{p'-p}{p'p}$. Further, this expression of the conditional variance of the mean can be used for pair of normal prior + posterior beliefs. This quantity is useful when taking expectation of next period's continuation value ■

D.3.2. Differences in Board and Shareholder Beliefs Within Period

This subsection explains exactly how Board and shareholder beliefs evolve within each period. As the wage and vote perfectly reveal signals z_b and z_s, the Board and shareholders share the same beliefs at the beginning of any period. Let τ_t be the tenure of the CEO at time t. By Prop. C.2, I have that $\sigma^2_{bt} = \sigma^2_{st} = \sigma^2_a(\tau)$ from (C.2). At the beginning of the period, let μ_{at} be the beliefs about the mean at the beginning of period t. So, I can describe Board and shareholder beliefs as $\left(\mu_{at}, \sigma^2_a(\tau_t)\right)$ at the beginning of period t.

1. **Board beliefs after the compensation committee meeting**

   At the meeting, the Board receives signal z_{bt}, and Board beliefs update to

$$\mu_{bt|z_b} = \sigma^2_{bt|z_b}\left(\frac{\mu_{at}}{\sigma^2_a(\tau_t)} + \frac{z_{bt}}{\sigma^2_{z_b}}\right) \tag{D.5}$$

$$\sigma^2_{bt|z_b} = \frac{\sigma^2_a(\tau_t)\sigma^2_{z_b}}{\sigma^2_a(\tau_t) + \sigma^2_{z_b}} = \sigma^2_0\left[1 + (\tau_t + 1)\kappa^{-1}_{z_b} + \tau_t(\kappa^{-1}_{z_s} + \kappa^{-1}_y)\right]^{-1} \tag{D.6}$$

   I use $\mu_{bt|z_b}$ and $\sigma_{bt|z_b}$ to follow conventions in the main text. The Board makes their wage decision based upon these beliefs. Before the wage is revealed, shareholders still maintain beliefs $\left(\mu_{at}, \sigma^2_a(\tau_t)\right)$.

2. **Shareholder beliefs when they commit to signal threshold k_{st}**

   When Board and shareholders play the wage-SOP game, their beliefs differ, in that the Board believes $\left(\mu_{bt|z_b}, \sigma_{bt|z_b}\right)$ and shareholders believe $\left(\mu_{at}, \sigma^2_a(\tau_t)\right)$. But shareholders can discern $\left(\mu_{bt|z_b}, \sigma_{bt|z_b}\right)$ for any z_{bt}, which they factor in when choosing their threshold. Shareholders thus factor in what $\mu_{bt|z_b}$ will be when calculating expected wages in their objective function in (17).

3. **Board and shareholder beliefs about shareholders' *ex ante* signal distribution at the time of the SOP vote**

   Before the SOP vote, when the shareholders commit to their threshold, both B and S know that the shareholders' aggregated signal will be

$$Z_{syt} = a + p\varepsilon_{st} + (1-p)\varepsilon_{yt} \tag{D.7}$$

with $Z_{syt} \sim N\Big(\mu_{at}, \sigma_{at}^2 + \frac{\sigma_{z_s}^2 \sigma_y^2}{\sigma_{z_s}^2 + \sigma_y^2}\Big)$.[4] Notice that shareholder beliefs about *a do not update* to $N\big(\mu_{bt|z_b}, \sigma_{bt|z_b}\big)$. This is because the timing convention in the model states that the wage w_t (and equivalently z_{bt}), productivity z_{yt} and the signal z_{st} are all revealed concurrently. At the exact time that z_{bt} and Z_{syt} are revealed, the Board and Shareholders may disagree about CEO skill. This timing convention is key for determining SOP outcomes.

4. **Board and shareholder beliefs after the annual shareholder meeting and release of 10-K**

   The 10-K and compensation committee report reveals the wage to shareholders, hence reveals z_{bt}. Shareholders vote at the annual meeting and Z_{syt} and thus z_{st} are revealed. Hence, B and S beliefs update to $\big(\mu_{at+1}, \sigma_a^2(\tau_t + 1)\big)$, by Prop. C.2.

D.4. Assumptions about Shareholder strategy

See Section 3.3 for the full discussion of the Shareholder's strategy. A primary goal of this paper is to model how the threat of SOP failure influences the Board's wage decision. I model this threat as an *ex ante* probability that the SOP will fail, which is increasing in the wage. In this spirit, the first assumption specifies precisely when shareholders commit to this threat.

Assumption 1. *Shareholders commit to their voting strategy in advance of the annual shareholder meeting.*

S must set their probability of failure *before* they receive their private signal or see wages and productivity. This threat of vote failure influences the Board's wage decision. The threat of vote failure does not need to be revealed to the Board before the annual shareholder meeting, however commitment forces S to play the threshold strategies that the Board expects. Unlike Kakhbod et al. (2023), there is no notion of cheap talk here. Commitment means S cannot choose an *ex ante* optimal non-zero failure probability and then renege at the shareholder meeting once the Board sets their wage.[5]

[4] The variance of the signal is $Var(a + p\varepsilon_{st} + (1-p)\varepsilon_y) = \sigma_a^2 + p^2\sigma_{st}^2 + (1-p)^2\sigma_y^2$, where $p = \frac{\sigma_{z_s}^{-2}}{\sigma_{z_s}^{-2} + \sigma_y^{-2}}$. Expanding this expression out leads to the expression for the variance.

[5] Based on Assumption 1, Figure A.6 provides a more detailed version of the model timeline (slightly adapting Figure 3). In particular, in period 1 (or 1a and 1b), B and S set their strategies. These strategies are not revealed at this time, but this timing convention defines the notion of the Board's informational advantage. In particular,

Assumption 2. *Shareholders seek to optimize operating income, given their beliefs about CEO ability.*

This assumption is a main source of disagreement about CEO ability between the Board and shareholders. The Board's signal z_{bt} causes B to update their beliefs about CEO ability. At the time that the Shareholder commits to their voting strategy, B and S hold different beliefs about CEO ability. This assumption means that S wants to force the Board to pay a wage closer to the unbiased wage, given their beliefs after receiving the signal at the shareholder meeting. Technically, this means that shareholders choose a single s_t for the Board's entire wage schedule — S influence expected wages. Or, put equivalently, S sets an average (across the distribution of z_{bt}) probability of SOP failure that the shareholder base is comfortable with.

Assumption 3. *Shareholders are* myopic. *That is, the SOP vote is only influenced by today, and is not a fully dynamic problem.*

Effectively, this means that shareholders play a static game, while the Board plays a dynamic one. This assumption matches reality. There is ample evidence that voting in SOPs is influenced by short-run outcomes, such as current firm or stock performance (see Figure A.4, or Fisch et al., 2018; Novick, 2019, 2020). Further, Table 2 Panel A shows that lagged CEO pay does not influence SOP outcomes. This makes the solution method much simpler, as it avoids higher-order beliefs and an infinite-regress problem in B and S forecasting each other's beliefs (Foster and Viswanathan, 1996; Bonatti et al., 2017).

D.5. Full Derivation of Model Solution

Proposition D.4. *The Board's problem can be written as*

$$V(\mu_a, \tau, w_{-1}) = \max_{w(s)} \quad \exp\left(\mu_{b|z_b} + 0.5\left(\sigma^2_{b|z_b} + \sigma^2_y\right)\right)w(s)^\alpha - (1-\lambda)w(s) - \chi_B F^U_{\tilde{z}_s}(s \times w(z_b, s)) - AC(w(s), w_{-1}; \tau) + \delta_B\left[f(\tau_t)V^R + (1 - f(\tau_t))E_{b|z_b}\left[V(\mu'_a, \tau+1, w(s))\right]\right] \tag{D.8}$$

the Board plays their strategy *after* receiving signal; the shareholder plays their strategy *before*. the assumption of commitment forces S to stick with the strategy that B expects.

where

- $\mu_{b|z_b}$ *and* $\sigma^2_{b|z_b}$ *are defined in* (C.5) *and* (C.6),
- $E_{b|z_b}[V] = F^U_{\tilde{z}_s}(s \times w)$ *where* $F^U_{\tilde{z}_s}$ *is the CDF of the following distribution (see 15)*

$$w^U \sim \log N\left(\frac{\mu_s}{1-\alpha} + C, \frac{\sigma_s^2}{(1-\alpha)^2}\right), \quad C = \frac{\log \alpha + \frac{1}{2}\sigma_y^2}{1-\alpha}$$

- $AC(w, w_{-1}; \tau)$ *(adjustment cost) is defined in* (3),
- $f(\tau_t)$ *are CEO tenure-specific hazard rates, with* $f_0 = 0$ *and* $f(\tau_t) = 1$
- $V^R = V(\mu_0, 0, 0)$ *as in* (20)
- $\mu_a' \mid \mu_{b|z_b}, \tau \sim N\left(\mu_{b|z_b}, \sigma^2_{b|_{z_b}} - \sigma_a^2(\tau+1)\right)$ *from Prop. C.3*

The shareholder's problem can be written as

$$\max_s \int_{z_b} f(z_b \mid \mu_a, \sigma_a^2)\left[\exp\left(\mu_a + 0.5\left(\sigma^2_{b|z_b} + \sigma_y^2\right)\right) w(z_b, s)^\alpha - w(z_b, s) - \chi_S CDF^U_s(s \times w(z_b, s))\right] dz_b \tag{D.9}$$

where $f\left(z_b \mid \mu_a, \sigma_a^2\right)$ *is the density function of* z_b *given prior beliefs about CEO ability, and all other objects are defined as above.*

Proof. I start with (C.8). $\mu_{b|z_b}$ and $\sigma^2_{b|z_b}$ are Board beliefs after receiving their signal, hence are known from the perspective of the Board. As $A = \exp(a + \varepsilon_y)$, with a (and beliefs about a) normally distributed, I can write its expectation in terms of means and variances. The probability of vote failure is described in Section 3.3, but as brief overview it is given by the CDF $F^U_{\tilde{z}_s}$, of the unbiased (lognormal) wage of beliefs implied by realizations of $\tilde{z}_s$. The adjustment cost makes the Board's problem dynamic, as they have to factor in the effect of wages on the continuation value.

V^R is value if the CEO retires, so beliefs reset and there is no adjustment cost. In other words, the Board's problem reverts to its $t = 1$ value; it is constant for any state as the prior belief of ability about the CEO talent pool is distributed $N(\mu_0, \sigma_0^2)$ for any state. Hence, it is a boundary condition.

The distribution of μ_a' conditional on μ_a and τ is given in Prop. C.3. However, because the Board has beliefs $\left(\mu_{b|z_b}, \sigma^2_{b|z_b}\right)$, the variance of next period *mean* beliefs (not the variance of beliefs) at the time the Board makes their decision is $\sigma^2_{b|z_b} - \sigma^2_{a'}$. This quantity wil be used to take expectation over the continuation value. If the CEO continues, the tenure increases by 1, and the Board must consider the adjustment cost in the next period.

For (C.9), the objects are the same as the Board's problem, however the shareholders choose s under the distribution of z_b, while holding belief of average CEO ability μ_a. That is, shareholders figure out the Board's wage decision for each z_b, including how they would react to the choice of a particular s. Under Assumption 3, shareholders do not behave dynamically, and only vote on the current period. Crucially, as the wage, the productivity signal and the shareholder's private signal are all revealed simultaneously (see Section 3.2 and Figures 3 and A.6), the Board and shareholders *disagree* about CEO ability at the point the vote is held. In other words, they hold different beliefs about (mean) CEO ability.

The solution $(w(z_b), s)$ is to be found numerically, each $(w(z_b), s)$ is a best response in equilibrium under commitment (Assumption 1). To sketch the intuition of the solution, fix S' strategy s under commitment. The Board can then back out the probability of failure for each choice of $w(z_b)$, knowing that S must play the threshold. In other words, there is no notion of deviation for the Board. S just needs to maximize (C.9) for their strategy to be a best response; they cannot deviate at the vote and play a lower threshold. ■

E. Estimation Appendix

E.1. Identifying the CEO component of output

To undertake my empirical analysis, I need to identify the CEO component of output. Consider the following functional form for the firm's log revenue

$$\log SALE_{jit} = \mu_i + \mu_t + \gamma_k \log PPE_{jit} + \gamma_e \log EMP_{jit} + a_i + \alpha \log w_{jit} + \epsilon_{it}^y$$

where j represents industry, i represents firm and t represents year. That is, revenue is composed of an industry-level, time-invariant component (μ_i), a time component (μ_t), contributions from capital and labor, the contribution of the CEO's ability and effort/wage, and finally a noise term. I am interested in the last three terms only. The issue with running this regression directly is that a regression directly including CEO fixed effects regression will not allow me to separately identify μ_i and a_i. To net out μ_i and a_i I first use data from 2000-2010 (pre-SOP), I estimate the following regression. For firm j in industry i and at year t,

$$\log SALE_{jit} = \mu_i + u_{jit}$$

under the constraint that the average value of μ_i equals the average value of $\log SALE$. The term μ_i thus represents the time-invariant industry-level average log output. Then, for the SOP period (2011-2020), I define $x_{jt} = \log SALE_{jit} - \mu_i$. I can drop the j subscript, as there is no longer an industry component. The functional form of revenue thus becomes

$$x_{it} = \mu_t + \gamma_k \log ppe_{it} + \gamma_e \log emp_{it} + a_i + \alpha \log w_{it} + \epsilon_{it}^y$$

By running this regression directly on the SOP period, then a_i directly identifies average CEO ability. Lastly, ϵ_{it}^y directly identifies the output innovation. My final CEO-specific log revenue measure is thus

$$y_{it} = a_i + \alpha \log w_{it} + \epsilon_{it}^y$$

This process is similar to the analysis undertaken in Matveyev (2017).

E.2. Numerical Solution

The model requires 11 parameters, along with $\mathbf{T} + 1$ externally calibrated CEO separation rates. I externally calibrate the Board's discount factor $\delta_B = 0.9$, following Taylor (2010). The CEO separation rates are generated by calculating the cross-sectional proportion of CEOs that separate from their firm for a given tenure. I group the remaining 10 parameters as Θ,

$$\Theta = \begin{pmatrix} \mu_0 & \sigma_0 & \sigma_y & \alpha & c_W & \sigma_{z_b} & \sigma_{z_s} & \lambda & \chi_B & \chi_S \end{pmatrix}$$

The model's solution proceeds as such

1. Start with a given Θ
2. Discretize each idiosyncratic shock into an N_z grid. E.g., fix the possible realizations of $\varepsilon_{z_{bt}}$, $\varepsilon_{z_{st}}$, etc.
3. Discretize the state space into a $(N_u, \mathbf{T}+1, N_w)$ grid, call it $\mathcal{S}$, where each tuple (μ_i, τ_j, w_k) indexes current mean belief about CEO ability, tenure (which fully determines beliefs of variance of CEO ability) and the current wage.
4. Start with a guess of $V_0(\mu, \tau, w)$ as the solution to the static game (i.e., where there is no wage adjustment cost), so V_0 is just the Board's per-period expected utility given optimal choices. Each $V(\mu, \tau, w_{1:N_w})$ starts with the same value.
5. Use Gauss quadrature and Prop. C.2 to estimate the continuation value for each tuple (μ, τ, w)
6. For each element in $\mathcal{S}$, solve (C.8) and (C.9),
   - If $i \,\%\, 10 = 0$
     - Solve B's optimal choice of w' given possible realizations of ε_{z_b}, and how this w' affects the continuation value and adjustment cost.
     - Concurrently backing out S' optimal choice of s for the tuple (μ, τ, w) given B's optimal choices of w'
     - Update the guess of the value function
   - Else,
     - Update B's optimal choices w'
     - Update the guess of the value function
7. Return to 4 and repeat until $\max|V_i - V_{i-1}| < \epsilon = 1\mathrm{e}-5$

This process returns the Board's wage policy for each element in $\mathcal{S}$, and each realization on the grid of ε_{z_b}. Concurrently, it returns the shareholder's policy for each element in $\mathcal{S}$.

E.3. Simulation

I set N_f firms, where N_f is chosen to match the number of firms in the data used for estimation. Given $a \sim (\mu_0, \sigma_0)$, I draw a CEO of skill a for each firm. A CEO spell is the length of time the CEO is matched with a firm. Each period, for each firm, I generate realizations of $\varepsilon_{z_{bt}}$, $\varepsilon_{z_{st}}$ and ε_{yt}. Given the state, I use the policies described in Section D.2 to generate optimal choices. Beliefs update given realizations of σ_{z_b}, σ_{z_s} and z_{yt}. At the end of each period, for CEOs with tenure $\tau > 0$, they separate (via firing, quitting or retirement) with exogenous probability f_τ.

I generate N_S samples for each simulation. I “fix" randomness across different simulations. That is, each $n_s \in N_S$ sample has the same seed across iterations, only the variance of each CEO ability and each shock changes.

E.4. Estimation

I estimate the 10 parameters

$$\Theta = \begin{pmatrix} \mu_0 & \sigma_0 & \sigma_y & \alpha & c_W & \sigma_{z_b} & \sigma_{z_s} & \lambda & \chi_B & \chi_S \end{pmatrix}$$

As mentioned above, the Board’s discount factor δ_B is calibrated to 0.9. (Taylor, 2010), and separation rates are calibrated to match observed separation rates in the sample. I estimate the remaining model parameters by finding a vector Θ of parameters that minimizes the weighting distance between a vector of moments produced by the model and the corresponding moments computed in the data. That is, given model moment $m(\Theta)$ and data moments $m(X)$ and an appropriate weighting matrix W, I minimize

$$\min_{\Theta} \left[d(\Theta, X)\right]' W \left[d(\Theta, X)\right] \tag{E.1}$$

$d(\Theta, X)$ is a 13×1 vector of differences between model-simulated and empirical moments (Barrero, 2022). I set $d(\Theta, x) = m(\Theta) - m(X)$. The weighting matrix is the identity matrix The model moments can be expressed as the coefficients from the following system of equations, where each regression is indexed by i, c, τ, t

$$
\begin{aligned}
\ln y &= y_0 + y_1 \ln \text{wage} + e_y \\
(E_{\text{CEO}}[\ln y] - E[E_{\text{CEO}}[\ln y]])^2 &= Var(E[\ln y]) + e_{\text{CEO}} \\
\ln \text{wage} &= b_0 + b_1 \mathbb{1}[\text{SOP fail}] + b_2 \ln \text{lagged wage} + e_b \\
\mathbb{1}[\text{SOP fail}] &= s_0 + s_1 \ln \text{wage} + s_2 \epsilon^y + e_s \\
(\epsilon^y)^2 &= Var(\epsilon^y) + e_{\epsilon_y} \\
\left(\epsilon^b\right)^2 &= Var\left(\epsilon^b\right) + e_{\epsilon_b} \\
(\epsilon^s)^2 &= Var(\epsilon^s) + e_{\epsilon_s} \\
y_{\mathbb{B}} &= \mathbb{B} x_{\mathbb{B}} + e_{\mathbb{B}}
\end{aligned}
\tag{E.2}
$$

For the final moment $\mathbb{B}$, I reconstruct (29) using a regression specification.[6] In total, there are 13 moments to pin down 10 parameters. I estimate (D.2) jointly, with standard errors clusted at the CEO-spell level, and use the variance-covariance matrix of the moments to estimate standard errors of the parameter and moments. The full list of moments with notation is displayed in Table D.1.

E.5. Optimization algorithm

My goal is to find the global minimum of the SMM/GMM objective function described in Section D.4. To leverage the efficiency of parallel computing, I use a somewhat modified version of the TikTak global optimization algorithm described in Arnoud et al. (2019).[7] The modifications are designed to take advantage of high performance computing to minimize computing time. The global optimization routine can be described as such:

1. **Parallel local minimization**

   i Generate bounds for each parameter. This is a holistic step, yet the bounds should be narrow enough to allow for the subsequent quasi-random sequences to adequately

[6] That is $x_{i,\mathbb{B}} = \sqrt{\frac{\hat{N}_b}{N_b}}$ and $y_{i,\mathbb{B}} = \left(x_{i,\mathbb{B}}\right)^{-1}(\mathbf{1}[x_b < 0] - \mathbf{1}[x_b \geq 0])\left(1 - \frac{\hat{N}_b}{N_b}\right)$. This expression reconstructs (29) in terms of a regression, and conveniently allows me to include (29) in our regression system.

[7] I modified code from https://github.com/tpapp/MultistartOptimization.jl, which is based upon the original TikTak code: https://github.com/serdarozkan/TikTak. See also Liu (2021) for a recent example.

Table E.1. Moment targeting exercise
This table displays the notation and description for each targeted moment, along with the parameter(s) it targets.

	Moment	Description	Target
(1)	$\hat{y}_0$	Average log output	μ_0
(2)	$\hat{y}_1$	Elasticity of output to wage	α
(3)	$\widehat{Var}(\epsilon^y)$	Output residual variance	σ_y
(4)	$\widehat{Var}(E[\ln y - \hat{y}_1 \ln w])$	CEO-average output variance	σ_0
(5)	$\hat{b}_0$	Average log wage when SOP passes	λ
(6)	$\hat{b}_1$	Difference in log wage when SOP fails	χ_B
(7)	$\hat{b}_2$	Persistence in log wages	c_w
(8)	$\widehat{Var}\left(\epsilon^b\right)$	Wage regression residual variance	σ_{z_b}
(9)	$\hat{s}_0$	Observed SOP failure rate	λ, χ_S
(10)	$\hat{s}_1$	Sensitivity of SOP failure to log wage	χ_B, χ_S
(11)	$\hat{s}_2$	Sensitivity of SOP failure to output shock	σ_{z_s}, σ_y
(12)	$\widehat{Var}(\epsilon^s)$	SOP fail regression residual variance	σ_{z_s}
(13)	$\widehat{\mathbb{B}}$	Bunching estimator (29)	χ_B, χ_S

cove the space, but wide enough so that I maximize the chance of finding the global minimum.

ii Using the bounds, generate a Sobol sequence of length N. Sobol points are quasi-random points which are intended to mimic a draw from from a uniform distribution. In my setup, I set $N = 5000$.

iii For each $n \in N$ of the Sobol points, use a minimizer to find the local minimum of each point. Keep the portion p of the points with the smallest local minima to be used in the global stage. In my setup, I use Nelder-Mead locally, and keep the top 4% of points, so I am left with $N_p = 200$ “promising" candidates for the global minimum.

2. **Parallel global minimization**. This step slightly modifies the TikTak routine to take advantage of parallel computing. I employ SLURM with MPI to enable communication between ranked sets of iterations across the N_p points. This allows me to speed up the TikTak global optimization step, though at the expense of far greater expenditure of computing resources.

i Take the $p \in N_p$ candidates for the global minimum from above and sort in ascending order. Set $i = 1$, so the best minimum so far is indexed by i.

ii Take the best minimum so far, labeled p_i^*. Generate $N_p - i$ convex combinations using the TikTak methodology. That is, for $j \in N_p - i$, $p_{ji}^{cand} = \theta_{ji} p_i^* + (1 - \theta_{ji}) p_j$, where $\theta_{ji} \in [0, 1]$ and approaches 1 as j increases.

iii Compute the local minimum of each $N_p - i$ point in parallel. If p_i^* is the best, then exit the routine and p_i^* is the candidate global minimum. Else,

iv For the first j such that function value of p_{ji}^{cand} is less than that of p_i^*, stop all subsequent (unfinished) local minimization routines for $j' \in N_p - i$, and $j' > j$. Update $i \mathrel{+}= p$ and return to ii.

This routine will return p_i^* as the global minimum.

3. **Polish global minimum**. Using stricter stopping criteria and a large number of function iterations, polish the global minimum p_i^* using a local minimization routine, i.e. Nelder-Mead.

E.6. Derivation of model statistics

This section derives several closed-form model statistics that are useful to interpret the magnitude of the main effects from the model. I can directly derive standard errors for closed-form functions of model parameters, which is useful for comparing across models.

SOP failure cost as a percentage of unbiased value. To interpret the magnitude of the SOP failure cost, I first develop a measure of unbiased firm value. Unbiased firm value is the discounted stream of future cash flows produced by the CEO if the CEO were paid the profit-maximizing wage, under the assumption that Board and shareholder beliefs remain fixed at (μ_0, σ_0^2). First, note that

$$w_0 = \arg\max_w E_0[A_0 w^\alpha - w] = \alpha^{\frac{1}{1-\alpha}} \times E_0[A_0]^{\frac{1}{1-\alpha}}$$

is the optimal unbiased wage, absent SOP. Using this, average (unbiased) firm value can be written as

$$\begin{aligned}
\text{Average firm value} = V_0 &= \sum_{t=1}^{\infty} \delta_B^t E_t[y_t - w_t] \\
&= \sum_{t=1}^{\infty} \delta_B^t E_0[y_0 - w_0] \\
&= \sum_{t=1}^{\infty} \delta_B^t E_0[A_0 \times (w_0)^\alpha - w_0] \\
&= \frac{1}{1-\delta_B}\left[\exp\left(\mu_0 + 0.5\left(\sigma_0^2 + \sigma_y^2\right)\right) \times (w_0)^\alpha - w_0\right]
\end{aligned}$$

I can use unbiased firm value to interpret the magnitude of the SOP failure cost parameters χ_B and χ_S

$$\text{SOP failure cost (\% average value)} = \frac{\chi_{\{B,S\}}}{V_0} \tag{E.3}$$

Board capture as a share of surplus. To interpret the magnitude of my board capture parameter, I can express it in terms of how the Board decides to split up the surplus between the Board and shareholder. Focusing on the average CEO in the first year of tenure, and abstracting from dynamics and SOP, suppose the Board places the weight $\nu \in [0,1]$ on the CEO's utility (pure dollar wage), and $1-\nu$ on company profits, so that their program is

$$\max_{w_t} \quad (1-\nu) \times E_0\left([A_0]w_t^\alpha - w_t\right) + \nu \times w_t$$

As can be seen, this is the same as $\max_{w_t} E_0[A_0]w_t^\alpha - (1-\lambda)w_t$, with $\lambda = \frac{\nu}{1-\nu}$, the main program from the paper. Equivalently defining $\nu = \frac{\lambda}{1+\lambda}$, if $\lambda = 1$, then the Board sets the wage such that company profits go to zero (perfect capture). If $\lambda = 0$, the Board maximizes profits. The optimal split that the Board decides for the CEO is thus

$$\theta_{\text{CEO}} = \frac{\nu w_t}{(1-\nu) \times (E_0[A_0]w_t^\alpha - w_t) + \nu w_t} = \frac{\lambda w_t}{E_0[A_0]w_t^\alpha - (1-\lambda)w_t}$$

The split θ_{CEO} describes how much the Board tilts the surplus towards the CEO. I can thus describe that the surplus split for the average CEO as

$$\theta_{\text{CEO}} = E_0\left[\frac{\lambda w_t}{y_t - (1-\lambda)w_t}\right] = \frac{\lambda w_0}{y_0 - (1-\lambda)w_0} \tag{E.4}$$