Effectiveness of Monitoring, Managerial Entrenchment, and Corporate Cash Holdings

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Abstract

We develop a dynamic model of a firm in which cash management is partially delegated to a self-interested manager. Shareholders trade off the cost of dismissing the manager with the cost of managerial discretion over the use of liquid funds. An improvement in corporate governance quality may have a positive or a negative effect on levels and values of cash balances, depending on the source of the improvement. While a reduction of managerial entrenchment results in lower cash balances and mostly higher marginal cash values, we demonstrate that the opposite is true when the monitoring of managerial actions becomes more effective. A managerial asset substitution problem produces a novel hump-shaped relation between the firm's liquidity levels and the collective propensity of shareholders and managers to reduce cash flow risk. We also discuss the firm's risk management strategies as well as derive implications of the presence of an investment opportunity, debt financing, and shareholder activism.

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1. Introduction

Economists as far back as Adam Smith (1776) have identified issues relating to the decision-making process of firms where agents do not bear the full extent of the wealth consequences of their actions. Corporate governance mechanisms have emerged to protect shareholders' interests against decisions that could be at the detriment to their wealth. Sufficient protection from foul play has enabled the separation of ownership and control, which – in turn – has led to the emergence and prevalence of corporations in modern times.

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Although it may be evident to many scholars that a firm's corporate governance influences its decision-making principles, it is sometimes less apparent how certain corporate policies are affected. In this paper, we seek to understand how the quality of a firm's corporate governance relates to the liquidity and risk management policies of a firm. We do this in an attempt to shed light onto conflicting evidence in the empirical literature investigating the afore-mentioned relations. Notably, although several studies report a negative relation between corporate governance and corporate cash holdings (Dittmar, Mahrt-Smith, and Servaes, 2003; Kalcheva and Lins, 2007; Chen, Chen, Schipper, Xu, and Xue, 2012), others document a positive relation (Harford, Mansi, and Maxwell, 2008) or, even, the inability to establish one or the other (Opler, Pinkowitz, Stulz, and Williamson, 1999; Bates, Kahle, and Stulz, 2009). Studies examining the effect of corporate governance on corporate risk management activities yield fairly mixed results too (Haushalter, 2000; Aretz and Bartram, 2010).

To elucidate these conflicting results, we develop a dynamic model of cash management in which we disentangle two key elements of corporate governance, managerial entrenchment and the shareholders' ability to monitor managerial actions. We use the model to examine their implications on cash holdings and risk-taking strategies of a firm. We also analyze effects that these two separate facets of corporate governance have on the value of corporate cash.

In the presented model, we draw a distinction between two discrete mechanisms through which shareholders can protect their investment: a) the limitation of managerial actions that directly destroy shareholder value (e.g., through the board's non-ratification of a negative-NPV investment or acquisition) and b) the ultimate disciplining action of replacing the company's management team (e.g., by enabling the market for corporate control). A deficiency in the ability to exercise any of these two mechanisms exacerbates the agency costs of managerial discretion. We relate the insufficiency of the former to *ineffective monitoring*, while we attribute the lack of credibility of the latter to *managerial entrenchment*. Although these two facets of governance are often hard to distinguish, they are explicitly separated from each other in the model to allow us to capture the complex effect that corporate governance can have on corporate policies.[1]

We embed inefficient monitoring and managerial entrenchment in a stylized continuous-time model of a firm facing the least amount of frictions required to justify positive but finite cash reserves: external financing costs and a cash return shortfall. We recognize two sets of reasons why cash reserves suffer a return shortfall; the first one represents a systematic liquidity discount related to market imperfections, while the second one is related to the effectiveness of a firm's board monitoring and reflects the ability of its manager to tunnel

[1] The distinction that we draw bears similarities with the contrast between internal and external control mechanisms (Gillan, 2006), but the overlap is not perfect. For instance, internal mechanisms (e.g., the board of directors) may ultimately be used to materialize the threat of replacing incumbent management, while the inefficiency of external mechanisms (e.g., the mergers and acquisitions market) can facilitate the inefficient empire-building tendency of managers.

corporate funds to her own benefit. Consistent with the findings by Bertrand and Schoar (2003) of the active role that managers play in setting corporate dividend policies, we assume that the payout decision is delegated to the firm's management. At the same time, shareholders maintain the equity issuance decision to allow for the disciplining role of the issuance process (Rozeff, 1982; Easterbrook, 1984) to be reflected in the amount raised from the market. As an ultimate control mechanism, shareholders hold the option to replace the manager, with the cost of doing so representing managerial entrenchment. The parsimonious but explicit incorporation of these two agency cost manifestations allows us to provide an explanation for the conflicting results found in the empirical literature on the effect of corporate governance on cash holding policies.

We show that, in the presence of a self-serving manager, the marginal value of a dollar of corporate cash is not monotonically decreasing in the level of cash reserves nor does it take values exclusively greater or equal to one, in contrast to the case of a firm free of agency concerns. Instead, the deviation from typical optimality conditions due to the shareholder-manager conflict results in a U-shaped cash value function with respect to the level of liquidity. As with prior contributions, liquidity is most valuable close to refinancing because this is when its function as a loss-absorbing buffer matters the most. Indeed, a positive amount of cash could be helpful for the firm to endure a temporary negative cash flow shock and prevent the incurrence of external financing costs. As cash reserves accumulate and the risk of (costly) refinancing recedes, the marginal value of cash drops. The manager's empire-building disposition induces hoarding of cash beyond shareholders' optimal disbursement point and eventually leads to an additional dollar of cash held inside the firm being valued below par. However, as the cost of keeping the manager at the helm of the firm mounts with excess cash, so does the moneyness of shareholders' option to replace her. The threat of dismissal forces the manager to ultimately pay funds out to shareholders, which restores the marginal value of cash back up to par right before payout. This non-monotonicity of the value of cash is a key feature of our model and generates novel testable implications for a firm's liquidity and risk management policies, as well as for the valuation of corporate cash holdings.

Our contribution to the literature is threefold. First, we isolate two key aspects underlying the shareholder-manager conflict and highlight the ambiguous relation between corporate governance and corporate cash levels. In our framework, greater managerial entrenchment and lower effectiveness of monitoring managerial actions, both notions associated with poorer shareholders' rights, have opposite effects on cash balances. On the one hand, an increase in the costs of searching for and implementing a change of the incumbent manager shields the latter from challenges unless the potential gain in value exceeds these costs. The heightened tolerance towards the firm's management results in a delay in cash distributions to investors. On the other hand, the increase in a manager's perceived tunneling activities as a consequence of less effective monitoring ensues an reduction of her relative contribution to firm value compared to shareholders' next best alternative, which she compensates for by hoarding less cash inside the firm. Taking into account the marked entanglement of these two governance facets, our model allows to explain the mixed results of empirical studies investigating the relationship between the overall quality of corporate governance and holdings of liquid assets.

Second, our paper demonstrates that the source of an improvement in a firm's governance matters when it comes to assessing the impact on the valuation of its corporate reserves. In particular, an extra dollar of cash is on average more valuable in firms with lower managerial entrenchment, e.g., in those facing more credible external threats. In the model, the effect of managerial entrenchment on the value of cash is purely indirect and a result of the suspension of payout until cash holdings accumulate at higher levels. In option pricing terms, lower managerial entrenchment implies a lower exercise price of the shareholders' option to replace incumbent management and therefore higher marginal values of cash, all else equal. In contrast, a unit of cash is less valuable in firms with tighter internal monitoring processes. This is not immediately expected because more effective monitoring mechanisms reduce the fraction of cash reserves being wasted in non-value increasing activities. As the complementing fraction of each cash dollar that remains in the firm's reserves is higher, this could be reflected in an increase in the marginal value of cash. This is, however, not the only consequence of a decrease in tunneling that is relevant for valuation purposes. Intuitively, it also involves an increase in the expected instantaneous cash flow to the firm and a delay in paying back funds to shareholders. Both of these effects of more effective monitoring diminish the contribution of a dollar of cash to avoiding external financing costs and to reaching the payout threshold respectively, and hence its value. Consequently, although both a decrease in managerial entrenchment and a decrease in tunneling activities lead to higher firm values, the former is largely associated with higher cash values while the opposite is true for the latter.

Third, our setup enables the analysis of the relation between the levels of corporate risk attitudes and cash holdings. Due to the suboptimality of the payout decision, the shareholders' value function is concave-convex over the range of cash holdings. In risk management terms, shareholders would prefer a reduction in the cash flow risk at lower levels of corporate cash, but would benefit from increased risk-taking at higher levels of cash. At the same time, managers would rather intensify risk-reducing activities as cash reserves grow due to the higher extraction of perks when the firm is cash rich. Interestingly, when managerial entrenchment is sufficiently high for managers to avoid replacement, they would even benefit from a temporary increase in the riskiness of a firm's cash flows when the cash balances are close to depletion. The mismatch in the convexities of the utility functions of the parties involved, and hence in their risk preferences, constitutes an expression of the shareholder-manager conflict and yields a rich set of results and implications.

The contrasting attitudes towards cash flow risk ascribe recognized agency problems to distinct sections of the cash holdings distribution. On the one hand, the risk-increasing tendency of managers at lower levels of cash is at odds with the shareholders' aversion for cash flow risk when the probability of refinancing is high. This managerial asset substitution problem mirrors managerial hubris behavior, manifestations of which include overconfidence of entrepreneurs (Hayward, Shepherd, and Griffin, 2006) and CEOs (Malmendier and Tate, 2005) as well as heightened corporate risk taking (Li and Tang, 2010). On the other hand, at higher levels of cash shareholders exhibit a preference towards risk taking while the manager's aversion to cash flow risk reaches its highest. This is in line with the managerial "quiet life" hypothesis (Bertrand and Mullainathan, 2003), according to which managers exhibit excessively cautious behavior, such as undertaking diversifying acquisitions, at the detriment of shareholder value (Gormley and Matsa, 2016). We find that a firm with entrenched management could experience either of these agency problems depending on the level of its cash reserves.

In the paper, we show that the change in the attitude towards risk from the two parties does not happen at the same level of cash holdings. In fact, there is a substantial intersection area where both shareholders and managers would benefit from mitigating the riskiness of cash flows. While the cash flow volatility depends to a great extent on the allocation of decision rights regarding the investment mix, we posit that an assumption of collective decision-making on risk setting results in an untested, to the best of our knowledge, hump-shaped relation between the level of liquid assets and corporate attitude towards risk taking. On the basis of a consensual risk management policy, our numerical implementation reveals that while the intersection interval, and hence the likelihood of observing active risk-reducing activities, shrinks with the effectiveness of monitoring, it grows with the restriction of managerial entrenchment. The shareholder-manager conflict is further demonstrated when risk management policies are explicitly analyzed. A greater ability of the manager to affect the firm's risk profile results in shareholders credibly demanding earlier payout but may also result in the region where both parties would consistently hedge to disappear. Similar to the result on cash holding levels, the conflicting effects of these two corporate governance facets supports the mixed empirical evidence.

Finally, we provide a number of extensions of the model by relaxing some of its key assumptions. We investigate first how refinancing and managerial payout policies are affected if the manager-run firm has access to an investment opportunity. We find that firm value increases with the probability of a positive NPV investment opportunity arising, as do cash reserves in most cases. Interestingly, for a sufficiently high investment cost, the manager may decide to give up shorter-term perks and pay out earlier in order to secure the longer-term benefit of a higher cost of her replacement if the investment is undertaken.

In a second extension, we incorporate debt financing, where coupon payments on risk-free debt delay payout and, hence, reduce firm value. Suboptimal cash policy leads to early default on risky debt. In line with Zwiebel (1996), the manager voluntarily relinquishes her entrenchment to secure refinancing when cash levels are close to depletion. Looking into the incentives to issue debt, borrowing has value for both shareholders and the manager. For the former, issuing debt prevents the incurrence of costly equity refinancing while, for the latter, it increases the pool of cash reserves from which perks are drawn. Although the optimal amount of debt to raise differs for the two parties, there is a substantial range of debt proceeds that is mutually beneficial.

In our final extension, we introduce a third party that threatens to force early payout upon arrival and may (in the case of a shareholder activist) or may not (in the case of a corporate raider) maintain the incumbent management at the helm of the firm. Firm value increases when the possibility of the arrival of such a third party is introduced. Compared to the base case, corporate cash reserves are higher (lower) prior to (after) an activist's intervention regarding the firm's payout policy. The gap between the pre- and post-arrival payout thresholds decreases with the post-arrival cost of managerial replacement and increases with the probability of the activist's arrival. When the arrival of the third party triggers managerial replacement (as with corporate raiders), the manager either adopts ex-ante the post-arrival cash policy to secure long-term benefits (tenure) or maximizes her short-term gains and gambles her position at the firm. She is more likely to opt for the former (latter) when the raider's negotiating power and the value of her outside option value are low (high), and the arrival rate of the raider is high (low).

Our modeling follows the literature on safety stock inventory models applied to liquid assets. The earliest contributions in the field include the discrete-time models by Baumol (1952), Tobin (1956), and Miller and Orr (1966), while more recently continuous-time models are proposed by Gryglewicz (2011), Bolton, Chen, and Wang (2011), Décamps, Mariotti, Rochet, Villeneuve (2011), and Anderson and Carverhill (2012). In all these articles, the payout and issuance decisions are complying with optimality conditions derived from a firm value maximization problem. In our framework, this is equivalent to a special case of perfect human capital market competition, that is, where equally-skilled agents compete in a world with non-existent replacement costs. We relax this implied assumption by introducing two agent-specific imperfections, which from a modeling perspective corresponds to suboptimal decision-making, and analyze their impact on the implications derived from past contributions.

Our work advances the strand of research that connects agency conflicts to financing, payout, and risk management decisions. Prior contributions include Jensen (1986), Zwiebel (1996), Morellec (2004), and Lambrecht and Myers (2008). All of these focus mostly on the leverage decision, but the underlying mechanisms bear similarities with our framework. Jensen (1986) argues that managers enjoy higher utility from managing firms with high cash flows, as they leave more room for managerial discretion over how these cash flows will be allocated. Increasing a firm's leverage restricts the agency costs of cash flow and thereby increases firm value. According to Zwiebel (1996), managers self-constrain their discretion by increasing the firm's debt levels to avoid challenges to their tenure. In a similar setup to ours, Morellec (2004) shows that managers use their discretion to overinvest while keeping debt levels low. In our model, managerial discretion is channeled through a retention of higher cash balances and a delay of payouts. As in Lambrecht and Myers (2008), the agency-free outside option of shareholders determines the firm's incumbent payout policy. Although we examine the same shareholder-manager conflict as these contributions, our paper focuses on the cash holding decision and the effect it has on refinancing and marginal values of cash.

The paper is organized as follows. Section 2 presents the model. Section 3 characterizes the issuance and payout policies of a firm under the helm of an entrenched self-serving manager. Section 4 derives comparative statics results on the levels and values of cash holdings. Section 5 sketches the implications of our model on corporate risk management policies, whereas Section 6 discusses extensions allowing for the presence of an investment opportunity, debt financing and shareholder activism. Section 7 concludes.

2. Model

We consider a firm operating a single project which generates continuous and random cash flows. The cumulative operating cash flow process (Y_t) is modeled as an arithmetic Brownian Motion, such that

$$dY_t = \mu\, dt + \sigma\, dW_t, \tag{1}$$

where μ represents the expected cash flows per period of time, $\sigma > 0$ the standard deviation of these cash flows, and dW_t the increment of a standard Wiener process defined over a probability space $(\Omega, \mathcal{F}, \mathbb{P})$ with the filtration $\{\mathcal{F}_t; t \geq 0\}$ satisfying the usual conditions of completeness and right-continuity. The firm is all-equity financed, has no growth opportunities and both the mean and standard deviation of cash flows are constant over time. All parties are risk neutral and discount cash flows at a rate $r > 0$.

Our model allows the firm to hold a non-negative amount of liquid assets in the form of cash reserves, the level of which at any point in time t is denoted by C_t. Changes in the cash balance follow the realizations of operating cash flows (dY_t). Note from (1) that the project may generate not only operating profits $(dW_t > -\mu/\sigma\, dt)$, but also operating losses $(dW_t < -\mu/\sigma\, dt)$. In the former case, a fraction of cash flows may be paid out to investors, with the remainder being retained inside the firm as liquid assets. In the latter case, negative cash flows may be funded either through internal (cash delpetion) or external financing.

In the presented framework, holding cash inside the firm is costly. We denote by λ the return shortfall on cash compared to the discount rate r used by agents. In the literature, this shortfall is interpreted as a result of market imperfections, such as tax distortions (Faulkender and Wang, 2006; Riddick and Whited, 2009), transaction costs giving rise to liquidity premia (Kim, Mauer, and Sherman, 1998; Vayanos and

Vila, 1999) or agency costs of cash stock. In the spirit of Jensen's (1986) free cash flow theory, the latter costs represent the degree of managerial discretion over the use of the firm's cash reserves, allowing for the manager's extraction of private benefits of control at the expense of shareholders.

Denoting by U_t the cumulative payout process and by I_t the cumulative net issuance process, the corporate cash inventory evolves thus according to

$$dC_t = dY_t + (r - \lambda)\, C_t\, dt + dI_t - dU_t, \tag{2}$$

which is the sum of the operating cash flow and the return generated on cash reserves in a time interval dt, plus the amount of external financing obtained, less the payout to shareholders during the same time interval.

Firms may raise funds to replenish their cash balance. Raising external financing in the capital markets is typically costly. Following Bolton et al. (2011), we assume that these costs consist of a proportional component amounting to $p-1 \geq 0$ for each dollar raised, as well as a fixed component $\phi > 0$ that is incurred by the firm each time financing occurs. For example, in order to finance a cash deficit of d dollars, the firm will need to issue securities for $p\,d + \phi$ dollars.[2] Hence, at any time t, the cumulative gross security issuance process J_t evolves according to

$$dJ_t = p\, dI_t + \phi\, 1_{dI_t > 0}, \tag{3}$$

where $1_{dI_t>0}$ is a indicator taking a value of 1 if financing takes place at time t and 0 otherwise.

Fixed and marginal costs have distinct roles in inventory control models. Positive fixed costs ensure that restocking happens in lumpy amounts while marginal costs introduce a wedge between the resetting targets of the state variable. For cash management models in particular, their inclusion is sufficient for reproducing respectively the stylized facts of intermittent financing and non-trivial time lags between financing and payout (see Décamps et al., 2011). The justification of these costs is not necessarily restricted to transaction costs associated with external financing, but also typically extends, especially in the case of marginal costs, to a reduced-form equivalent of adverse selection costs (Hennessy and Whited, 2007; Riddick and Whited, 2009) that would prevent investors from replenishing cash reserves to the full. The absence of marginal issuance costs from a traditional cash management model would result in a payout taking place immediately after a new security issuance, conflicting thus with empirical findings (Leary and Roberts, 2005).

By introducing a conflict of interest between shareholders and managers, even in a parsimonious fashion,

[2] A variant of this design would be to assume instead that the fixed cost is paid directly by the issuer rather than the financier, such that the fixed cost component is also subject to proportional costs, as in, e.g., Décamps et al. (2011) and Décamps et al. (2017). In modeling terms, this would mean that the firm needs to issue securities for $p\,(d+\phi)$ dollars. Altering the modeling of issuance costs has no qualitative impact on our findings.

we avoid the need for the proportional cost parameter to reflect agency considerations, refining thus its scope to capturing solely the direct effect of marginal issuance costs. Indeed, in our framework, unlike in previous contributions, a positive marginal cost is not necessary for a material time interval between refinancing and payout to exist. That is, the probability of a share repurchase immediately after new financing has been attracted is zero even in the absence of marginal brokerage fees, that is, for $p = 1$. As further discussed in Section 3.2.1 below, this result is directly linked to the U-shape of the marginal value of cash in the model, caused by agency costs.

We model the shareholder-manager conflict by allowing the firm's liquidity policy to be partially delegated to a self-serving manager who is also able to tunnel the agency component of the cost of carrying cash, $\lambda\, C_t\, dt$, to her own benefit. Similar to existing cash accumulation models (Décamps et al., 2011; Bolton et al., 2011; Nikolov and Whited, 2014), we assume that the level of resources that the manager can tunnel out of the firm is proportional to the level of the firm's cash reserves. Given that our model's main mechanism is based on the comparison of shareholders' value under incumbent management relative to their outside option, λ is interpreted on the basis of agency costs in the base case of our model. As a counterbalance, shareholders control the equity issuance decision[3] and hold the right to replace the manager whenever they see it fit. Upon managerial dismissal, i.e., at time τ^L, the firm is liquidated for an equivalent of $L\left(C_{\tau^L}\right)$, the supremum value among the subset of alternatives that shareholders have regarding their option value on the firm's assets.[4] That is, the liquidation function $L\left(\cdot\right)$ represents the value of shareholders' best outside option.

Following Lambrecht and Myers (2008), we assume that replacing the manager eliminates the agency problem, yet entails costly collective action.[5] Upon liquidation, shareholders receive the payoff they would be entitled to if they were shareholders of an equivalent firm where the manager's interests are fully aligned with theirs – there is no tunneling of cash nor any other imperfection resulting in return shortfall ($\lambda = 0$) and liquidity policy decisions are maximizing shareholder value; yet, the value of operations is reduced by a fraction γ. To illustrate this point, consider the payoff to shareholders of the agency-free firm as the sum of

[3]Our model is based on the assumption that neither party can credibly threaten to give up the value they gain from their relationship unless they hold a more valuable outside option. Given the limited options of the manager (her outside option is normalized to zero), our assumption of shareholder control over the equity decision is a consequence of our assumption of perfect information. Yet, in reality, information is more often than not imperfect and there is empirical evidence suggesting that voting on corporate decisions is manipulated by managers (Bach and Metzger, 2019) and that shareholders' ability to control new public equity issuances varies across markets (Holderness, 2018). We discuss the impact of allocating one additional decision over the equity issuance, either timing or amount issued, to the manager in Appendix A.4.

[4]As made clear further on, the mechanism of our model does not rely on the manager's dismissal as such, but rather on the threat thereof. Whether the firm will continue its operations under new management or will be liquidated is of little importance in our setup, and hence, the terms "managerial dismissal", "managerial replacement" and "liquidation" are used interchangeably.

[5]This assumption implies that, in this paper, shareholders' best alternative option is to take the firm private, i.e., operate the firm themselves. An extension allowing for a choice among a continuum of intermediate options between the incumbent management and full alignment is within the bounds of our framework, but would introduce unnecessary complexity here with no real benefit to the scope of this study.

the value of the cashless firm and the value of its cash reserves. Denoting the former by a^L and the latter by $m^L(C)$, the liquidation function can be expressed as[6]

$$L(c) = (1-\gamma)\, a^L + m^L(C). \tag{4}$$

The loss in value generated by the parameter γ need not be restricted to the cost of collective action; alternative interpretations would include a severance package or a loss of human capital due to the manager's dismissal.[7] What is of essence for our model is the existence of a wedge between the shareholders' payoff under incumbent management and the value of their outside option, which creates a space for managerial rents to materialize. We refer to any such cost of managerial replacement as "managerial entrenchment".

Importantly, managerial entrenchment is a theoretical foundation that allows for the partial transfer of decision rights to a self-serving manager leading to liquidity policies that do not necessarily maximize shareholder's value. The allocation of decision rights in the presented setup stems from the implicit contract between the two parties. The manager holds control rights over the firm's cash with the shareholders maintaining the respective residual rights. This implies that while shareholders cannot explicitly force the manager to pay out, they can threaten to dismiss her. The manager does not release funds to shareholders unless she knows that they may act upon this threat, that is, they have an at least equally valuable outside option. Equivalently, the manager cannot force refinancing nor has any control on the amount of cash to be injected in the firm when refinancing occurs. The implicit assumption is that the manager does not have equally valuable alternatives for her human capital and thus cannot credibly threaten to terminate her contract with the shareholders. Given her set of outside options, her optimal strategy simplifies to ensuring that she remains the shareholders' best option.

We set the objective of the manager as the choice of the payout policy that maximizes the present value of her rents. Recall that these are equal to a proportion λ of cash reserves that she is able to tunnel to her own benefit for as long as she remains in office. After her dismissal, she is assumed to remain unemployed ever after. The manager's problem can thus be expressed as

$$\sup_{u \in \mathcal{U} | (i^* \in \mathcal{I}, \tau^{L*})} \mathbb{E}\left[\int_0^{\tau^{L*}} \lambda\, C_t\, e^{-rt} \mathrm{d}t\right], \tag{5}$$

[6]Given their limited liability, shareholders also hold an abandonment option they would exercise as soon as their payoff turned negative. Hence, formally, the liquidation function can be written as

$$L(C) = \max\left[(1-\gamma)\, a^L + m^L(C),\, 0\right].$$

The exercise of this abandonment option is of limited importance to the scope of this study and, therefore, in both the theoretical solution and the numerical implementation that follow, we limit the analysis to parameter values for which the liquidation function is strictly positive.

[7]In fact, our interpretation of γ is related to CEO power and, as such, is not limited to direct costs of managerial replacement, but also indirect ones, such as the loss of managerial talent (Song and Wan, 2019).

where C_t is the regulated cash process described by (2), $\mathcal{U}$ is a set of admissible cash distribution policies (u), $i^* \in \mathcal{I}$ is the value-maximizing shareholders' issuance policy from the set of admissible policies and τ^{L^*} is the shareholders' optimal timing of managerial removal.

Shareholders' objective is to choose the refinancing (i) and liquidation (τ^L) policies that maximize the value of their shares. Their optimization problem can thus be expressed as

$$\sup_{(i \in \mathcal{I},\, \tau^L) | u^* \in \mathcal{U}} \mathbb{E}\left[\int_0^{\tau^L} (dU_t - dJ_t)\, e^{-rt} + L(C_{\tau^L}) e^{-r\tau^L}\right], \tag{6}$$

where $u^* \in \mathcal{U}$ is the optimal manager's payout policy. The first term inside the brackets represents the present value of their payoffs under incumbent management, that is, the firm's total payout net of the claim of new investors. The second term represents the present value of their outside option.

3. Model solution

In order to solve the problem described in Section 2 and summarized by equations (5) and (6), we need first to determine the value of shareholders' outside option $L(c)$. Recall that the liquidation function is the value of an agency-free but otherwise identical firm, adjusted for the cost of collective action γ. Hence, the valuation of $L(c)$ is closely related to the value of an agency-free firm, which we denote by $V^L(c)$ and also use as a benchmark for comparative statics analysis. Determining $V^L(c)$ follows the solution in Décamps et al. (2011), a summary of which is reproduced below.

Fixed costs of financing induce shareholders to delay refinancing as much as possible.[8] In the absence of a credit line, external funding is not pursued until cash reserves are fully depleted.[9] Costly refinancing adds value to cash and shareholders refrain from paying it out until the marginal benefit of doing so is higher than the marginal cost. In this "inaction" region, that is, where neither refinancing nor payout occurs, the cash accumulation process of the firm evolves according to

$$dC_t = dY_t + (r - \lambda)\, C_t\, dt, \tag{7}$$

where λ is interpreted for the agency-free firm as a result of market imperfections unrelated to the agency problem. Standard dynamic programming arguments yield the following ordinary differential equation (ODE):

$$r\, V^L(C) = \big[\mu + (r - \lambda)\, C\big]\, V^L_C(C) + \frac{\sigma^2}{2}\, V^L_{CC}(C), \tag{8}$$

[8] The original model in Décamps et al. (2011) also allows for the liquidation of the firm if financing costs are prohibitively expensive. Consistently with footnote 6, we do not treat here cases that lead to the exercise of this abandonment option.

[9] For the treatment of credit lines in dynamic cash management problems, the reader is referred to Bolton et al. (2011) and Décamps et al. (2017).

where f_C and f_{CC} generally denote, respectively, the first- and second-order derivatives of a function f with respect to its argument, C.

Since the proportional cost λ of holding cash is constant, any cash exceeding a threshold level $\overline{C}^L$ where the marginal benefit and cost of holding cash equate, is paid out to shareholders. Hence, for an infinitesimal payout increment ϵ, the value function V^L satisfies

$$V^L\left(\overline{C}^L\right) = V^L\left(\overline{C}^L - \epsilon\right) + \epsilon. \tag{9}$$

At the payout threshold $\overline{C}^L$, one dollar of cash inside the firm is worth to shareholders just as much as one dollar of cash outside the firm. Hence, $\overline{C}^L$ acts as a reflecting barrier where

$$V^L_C\left(\overline{C}^L\right) = 1. \tag{10}$$

The maximization of shareholder value at the payout threshold implies the condition:[10]

$$V^L_{CC}\left(\overline{C}^L\right) = 0. \tag{11}$$

Turning to the refinancing policy, recall that refinancing costs consist of a fixed and a proportional component. Due to the former, it is beneficial for shareholders to issue lump sums of new equity whenever financing is needed. At the time of issuance, that is, at $c = 0$, the value-matching condition is

$$V^L(0) = V^L(\widetilde{C}^L) - p\,\widetilde{C}^L - \phi, \tag{12}$$

where $\widetilde{C}^L$ is the refinancing target of the agency-free firm. When choosing the target level of refinancing, shareholders weigh the benefit from delaying the next equity issuance against the direct proportional cost of the current issuance. The optimal amount of new securities issued is given by the following smooth-pasting condition:

$$V^L_C(\widetilde{C}^L) = p. \tag{13}$$

The value function satisfying conditions (8) to (13) is an increasing and concave function of the level of

[10]Expanding $V(\overline{C}^L - \epsilon)$ in (9) yields

$$V^L(\overline{C}^L) = V^L(\overline{C}^L) - V^L_C(\overline{C}^L)\epsilon + \epsilon \Longrightarrow V^L_C(\overline{C}^L) = 1$$

Hence, in our case, equation (10) is a value-matching condition, although it involves a first-order derivative of the value function. Optimality requires the first-order derivative of the value function at the target cash levels after payout to equal one minus the marginal cost of payout. The latter being equal to zero in our setup, we get

$$V^L_C(\overline{C}^L - \epsilon) = 1 \Longrightarrow V^L_C(\overline{C}^L) - V^L_{CC}(\overline{C}^L)\epsilon = 1$$

Substituting condition (10) yields (11), which is the smooth-pasting condition at $\overline{C}^L$ although it involves a second-order derivative. See Dumas (1991) for a detailed note on boundary conditions involving infinitesimal regulation.

cash reserves C, where the marginal value of cash is strictly greater than one for $C < \overline{C}^L$ and equal to one at $C = \overline{C}^L$.

Shareholders' outside option is assumed to be equal to the limiting case of the agency-free firm with no cash shortfall ($\lambda = 0$) net of cost of collective action to dismiss the manager.[11] Given that the value of cash is zero at $C = 0$, that is, shareholder value is equal to the value of the cashless firm as defined in (4), the liquidation function $L(C)$ is given by

$$L(C) = (1-\gamma)\ \underbrace{V^L_{\lambda=0}(0)}_{\substack{\text{Value of}\\ \text{cashless}\\ \text{firm, } a^L}} + \underbrace{\left[V^L_{\lambda=0}(C) - V^L_{\lambda=0}(0)\right]}_{\substack{\text{Value of}\\ \text{corporate}\\ \text{cash, } m^L(C)}}. \tag{14}$$

Having determined shareholders' liquidation function, we now turn to the cash policy and shareholder value for a firm controlled by a self-serving manager. The intuition of the model is that shareholders will exercise their option to replace the manager as soon as the value of their outside option exceeds the value of their claim under incumbent management. We denote the value of shareholders' claim in the firm run by the self-interested manager by $V(C)$ ($\geq L(C)$). The shape of $V(C)$ depends on shareholders' policy regarding the dismissal of incumbent management.

Given the lack of an equally good outside option for herself, the manager will act in a way that maximizes her rents while delaying her replacement as much as possible. Because of her inability to credibly precommit to future dividend payments, the manager has no incentive to pay out to shareholders before it becomes necessary for retaining her tenure. On the other hand, and similar to the agency-free firm, shareholders are better off delaying the incurrence of refinancing costs until cash reserves are completely depleted. Hence, in this case too, there is an inaction region where cash reserves accumulate according to (7) and shareholders' value satisfies the ODE (8). Recall that managerial entrenchment creates a wedge between the shareholder's expected value under incumbent management and the value of their outside option, which results in shareholders' tolerance of the manager's adverse spending. The tunneling activity of the manager determines the rate at which this wedge thins with liquid assets and essentially sets out the conditions of her tenure. Naturally, there is a critical level of perceived tunneling $\bar{\lambda}$ above which, or a degree of managerial entrenchment $\underline{\gamma}$ below which, the cost of keeping the manager in charge of the firm becomes so high, or the cost of dismissal so low, that she is unable to maintain her position no matter the payout policy she implements.

[11] For $\lambda = 0$, there is no benefit from paying out corporate cash and thus conditions (10) and (11) are replaced by

$$\lim_{C \to +\infty} V^L_C(C) = 1$$

A version of the model where the cash balance of the shareholders' outside option is also subject to the return shortfall $0 < \lambda^L < \lambda$ has also been considered by the authors. Its conclusions are the same as the ones based on the more parsimonious setup presented in the paper.

Although these cases are also of interest and may be worth exploring further, we focus our analysis to values of the tunneling parameter that allow for at least one payout policy guaranteeing the manager's tenure. For completeness, we outline the conditions for the solution of cases where $\lambda > \bar{\lambda}$ at the end of this section.

For $\lambda \leq \bar{\lambda}$, we conjecture that the manager is able to exercise a payout policy that permanently secures her position inside the firm. To illustrate this, consider the possibility that the manager exercises the payout policy that maximizes shareholder value, as described for the case of the agency-free firm above, with the cost of carry equal to λ. For such a policy and for a given managerial entrenchment parameter γ, there is a λ sufficiently small such that the shareholder value for the firm run by the self-interested manager exceeds the value of the outside option, that is, the cost of collective action outweighs the loss due to the extra cost λ of carrying cash. As long as this is the case, there is room for the manager to extract additional perks from her position.

Given that the amount she can expropriate at a given instant is linear in cash balance, the manager is better off delaying payout, that is, she has incentives to initiate payout at the level of cash that is suboptimally high from shareholders' perspective, conditional on λ. As the payout trigger deviates from the optimal level, the cost of holding an extra dollar of cash inside the firm exceeds the benefit of doing so, and thus the marginal value of cash drops below one. This means that shareholders' claim grows at a lower rate than the value of their outside option with respect to cash, and hence, there is a level of cash holdings above which keeping the manager in charge of the firm is so costly that her dismissal becomes optimal.[12] To maintain her position, the manager needs to pay out as much as necessary so that cash never exceeds shareholders' indifference level, that is, the level of cash at which their value in the firm run by the self-interested manager is equal to the value of their outside option. Denoting the payout trigger by $\overline{C}$, this managerial constraint can be expressed as

$$V(\overline{C}) = L(\overline{C}). \tag{15}$$

Denoting the level of cash after payout by $\overline{C} - b$, the shareholders' value function satisfies

$$V(\overline{C}) = V(\overline{C} - b) + b. \tag{16}$$

Given that the payout threshold $\overline{C}$ is the highest possible cash stock that will ensure her tenure, it is the point at which her managerial rents are at their peak and, in the absence of a fixed cost of payout, paying out a lump sum to shareholders will only reduce her perks in the next time increment.

Therefore, the manager value maximizing policy is to distribute any cash flow which, added to the existing cash reserves, exceeds this payout threshold, that is, $b = 0$. Taking the limit of (16) as b approaches to zero

[12] Recall that the marginal value of cash in the agency-free firm is bounded downwards at one.

yields

$$V_C(\overline{C}) = 1. \tag{17}$$

When the firm's cash reserves are depleted, that is, at $c = 0$, shareholders decide how much cash is going to be invested in the firm by choosing the amount of new equity to be issued. Recall that the refinancing policy is chosen unilaterally by shareholders and that their payoff is diluted every time that an issuance occurs due to the costs of external financing. As long as the manager remains in her position after refinancing, the shareholders' payoff function satisfies

$$V(0) = V(\widetilde{C}) - p\,\widetilde{C} - \phi, \tag{18}$$

where $\widetilde{C}$ represents the net issuance proceeds. These are optimally chosen by shareholders to maximize the value of their claim and therefore satisfy the first-order condition:

$$V_C(\widetilde{C}) = p. \tag{19}$$

The critical level of tunneling, $\bar{\lambda}$, for which the ODE (8) and conditions (15) to (19) are satisfied is defined as the level for which the payout threshold $\overline{C}$ equals the optimal payout threshold that would have been chosen by shareholders running an agency-free firm with a cost of carry $\bar{\lambda}$, denoted by $\overline{\overline{C}}$. As long as $\lambda \leq \bar{\lambda}$ (or, equivalently, $\overline{C} \geq \overline{\overline{C}}$), the manager is able to retain her position indefinitely. Proposition 1 summarizes the results:

Proposition 1. *For a firm run by a sufficiently entrenched self-serving manager, it holds that*

1. *The value of the firm, $V(C)$, is an increasing function of its cash stock c, concave for $c \in [0, C^*)$ and convex for $C \in (C^*, \overline{C}]$, where $0 < C^* \leq \overline{C}$.*
2. *The marginal value of cash, $V_C(C)$, is strictly higher than one in the interval $[0, C_1)$, strictly lower than one in the interval $(C_1, \overline{C})$ and equal to one for $C = C_1 < C^*$ and $C = \overline{C}$.*
3. *Payout occurs when the accumulated cash reaches the payout threshold $\overline{C}$, which acts as a reflecting barrier.*
4. *Equity issuance occurs whenever the firm runs out of cash, that is, at $C = 0$, at which point shareholders replenish cash reserves up to $\widetilde{C} \leq C_1$.*

Although further developed below, it is worth noting a key result of Proposition 1. Unlike previous contributions of cash accumulation models (Bolton et al., 2011; Décamps et al., 2011; Décamps et al., 2017), the value to shareholders is not strictly concave throughout its support $(0, \overline{C})$. Instead, it is concave for low values of cash, but convex for high values of cash. This in turn implies that although shareholders would not benefit by an increase in the riskiness of cash flows when the firm is running low on liquid assets, they would welcome such an increase in risk when liquidity exceeds the level that maximizes the value of their share. Hence, our framework allows shareholders to gain from policies that decrease cash flow risk, but from also ones that increase it, depending on the level of cash. The risk management implications of this result are further discussed in Section 5.

Another key result, related to the ensuing U-shape of the marginal value of cash, is that the value of one dollar of cash inside the firm drops below its face value for high levels of cash. In our framework, a unit of cash in corporate reserves does not always add value to shareholders as a marginal value below one indicates that this unit of cash would be more valuable if it were in their personal reserves (gaining the opportunity rate of return r) instead.

Before turning to the analysis of our model, we outline below the conditions that solve for the firm value $V(C)$ in the range of values where conditions (15) to (19) are not satisfied. As already mentioned, Proposition 1 holds as long as the manager's tunneling activity is sufficiently low to allow for $\overline{C} \geq \overline{\overline{C}}$. If not, there is no payout policy that would guarantee her position in the firm. Indeed, for $\lambda > \bar{\lambda}$, the manager's constraint (15) cannot be satisfied as paying out suboptimally early, that is, at a cash level below $\overline{\overline{C}}$, would only decrease the value to shareholders even further. This means that the manager is not able to indefinitely delay her dismissal and shareholders exercise their option as soon as cash holdings reach a level of cash C^l where

$$V\big(C^l\big) = L\big(C^l\big). \tag{20}$$

Shareholders exercise their option to dismiss the manager in a way that maximizes their payoff and therefore C^l satisfies the following first-order condition:

$$V_C\big(C^l\big) = L_C\big(C^l\big). \tag{21}$$

As long as C^l is higher than $\widetilde{C}$ as determined by the remaining conditions (18) and (19), the manager holds her position for any cash level $C < C^l$. Note that any attempt to pay out to shareholders triggers an immediate dismissal.

Lastly, when λ exceeds the level for which $C^l \geq \widetilde{C}$, the manager is also dismissed when cash reserves are depleted. In such cases of extreme tunneling, conditions (18) and (19) are substituted by

$$V\big(0\big) = L\big(0\big). \tag{22}$$

4. Results

For the baseline firm, we set both the expected operating cash flow μ and its volatility σ to 0.18. We choose to set $\mu = \sigma$ as this entails that the probability of a negative cash flow occurring is approximately

$\Phi(-1) \approx 16\%$, in consistency with observed data.[13] We set the return of the risk-free asset to $r = 4\%$ and the carry cost of cash to $\lambda = 1.5\%$. The operating assets' value loss upon managerial dismissal, that is, the managerial entrenchment parameter, γ, is set to 6.5%.[14] Lastly, we set $\phi = 0.01$ and $p = 1.03$, resulting in financing costs of 10.5% of the gross equity issuance for the baseline case.

The solution based on these parameter values results in a cash ratio of 16.9% at payout ($\overline{C}/V(\overline{C})$) and 2.6% upon refinancing ($\tilde{C}/V(\tilde{C})$) for the firm under the control of the entrenched manager.[15] These ratios are 6.7% and 3.1% respectively for the benchmark agency-free firm.

Prior to analyzing effects of all relevant parameters on cash management policies and values, we first highlight the implications of introducing a self-interested manager to our setup.

4.1. Policy and value implications of managerial entrenchment

Proposition 1 describes a non-monotonic relation between the marginal value of cash and levels of cash: the marginal value of cash decreases with cash at low levels, but increases with cash when its balance is relatively high. Panel (a) of Figure 1 plots the marginal value of cash for the firm run by the self-interested manager (solid line) and the respective function for an – otherwise identical – agency-free firm (dashed line). The frictionless marginal value of cash ($V_C^{FB} = 1$) is depicted by the dotted line. The U-shape of the marginal value of cash is a result of the suboptimal payout decision caused by the introduction of the self-interested manager and the ensuing second-best equity issuance decision by shareholders.

[Please insert Figure 1 about here]

For the ease of analysis, we decompose the value of corporate cash into three components: its face value, its precautionary benefit, and its opportunity cost; and define the net marginal value of cash as the difference between the precautionary benefit and the opportunity cost of holding an incremental unit of cash in the firm rather than outside of it.[16] The precautionary benefit of one dollar of cash reflects the contribution of this dollar to the decrease in the probability of the firm incurring external financing costs; while the opportunity

[13] Indicatively, the frequency of negative cash flows per firm with at least 10 years of data in Compustat is once every 6.7 years. By setting $\mu = \sigma = 0.18$, we diverge to some extent from numerical values of $\mu = 0.18$ and $\sigma = 0.09$ used in previous contributions (e.g., Bolton et al., 2011; Décamps et al., 2011), as the resulting μ/σ ratio implies a very modest, in comparison, probability of a negative cash flow (just 2.3% per year). Our baseline values have been chosen purely on realism and expositional purposes; setting $\sigma = 0.09$ has no qualitative impact on our results.

[14] In a related setup, Lambrecht and Myers (2008) set costs of collective action for firms with strong investor rights to 3% of net operating assets, and those for weak investor rights to 10% respectively. We use the midpoint for our baseline case.

[15] Or, equivalently, gross equity proceeds ($(p\tilde{C} + \phi)/V(0)$) of 3.0%.

[16] In other words, the net marginal value of cash is the marginal value of cash net of its face value ($V_C - 1$).

cost reflects the loss in value that is due to the slower rate at which cash effectively accumulates inside the firm rather than outside of it ($r - \lambda$ rather than r).

As discussed above, the wedge between the value of the firm and that of the outside option, created by managerial entrenchment, allows the manager to delay payouts and, most importantly, to accumulate liquid funds uncontestedly. Although delaying payout increases both the precautionary benefit and the opportunity cost of holding cash, the effect of the latter prevails. This is to be expected since the policy under examination constitutes a deviation from the optimal payout level where, under the optimal payout policy, they would equate. As a consequence, the total value of cash drops, and so does firm value.

Next, we separate the effect of introducing a self-interested manager on the two components of the net marginal value of cash. Higher payout thresholds lead to higher marginal precautionary benefits as the extension of the cash reserves' upper limit lends more scope to every dollar of cash for avoiding issuance costs. For instance, the marginal precautionary benefit of a dollar of cash at $\overline{C}^L$ for the agency-free firm is zero. At the same time, the same dollar has a positive precautionary value in a firm run by the self-interested manager as its addition to cash reserves (recall that $\overline{C}^L < \overline{C}$) decreases further the probability of incurring the costs of external financing. It also holds that setting a higher payout threshold entails primarily a higher marginal opportunity cost as every dollar of cash in corporate reserves contributes less to increasing the probability of hitting the payout trigger. Taking the same limiting example as before, the marginal opportunity cost of a dollar of cash received at $\overline{C}^L$ for the agency-free firm is zero and, considering the marginal precautionary benefit of zero, the market value of this dollar of cash is equal to its face value ($V_C = 1$). Instead, the same dollar of cash, that is, one received at the same level of corporate cash reserves, has a positive opportunity cost in the firm run by the self-interested manager as it yields a lower return than the prevailing return in the market. Even after adding up the marginal precautionary benefit, deviating from the optimal payout policy means that the marginal cost exceeds the marginal benefit, resulting thus in a negative net (i.e., below the par value) marginal value of cash.

Multiple results ensue from this drop in the marginal value of cash. First, the marginal value of cash drops below its face value ($V_C < 1$) for a substantial range of cash levels. This means that in this range one dollar of cash is more valuable in the pockets of shareholders rather than in corporate reserves. Note that our framework allows for a marginal value of cash lower than one despite the absence of a fixed cost of distribution, which would otherwise be needed in an agency-free cash model to generate a similar feature. This value shortfall is very much in line with empirical evidence of cash market values being estimated at levels lower than one dollar (Faulkender and Wang, 2006; Pinkowitz, Stulz, and Williamson, 2006; Dittmar and Mahrt-Smith, 2007; Pinkowitz and Williamson, 2007). Panel (b) of Figure 1 highlights that, depending on parameter values, this effect may be so substantial that the *total* value of cash inside the firm could drop below its face value ($V(C) - V(0) < C$).

Second, the drop in the value of cash results in fewer net proceeds from equity issuances when the firm seeks financing, that is, $\tilde{C} < \tilde{C}^L$. As cash under the control of an entrenched manager becomes less valuable for investors, they are willing to inject a smaller amount of funds compared to an otherwise identical agency-free firm.

Third, the marginal value of cash is U-shaped with respect to cash levels. As cash reserves accumulate and approach the payout trigger, both the marginal precautionary benefit and the marginal opportunity cost of a dollar of cash shrink and eventually disappear, leading to the marginal cash value converging to its face value. Given that the marginal value of a dollar of cash is valued at less than one dollar (see above) for high levels of cash, this implies that above a certain level of cash reserves C^* and closer to the payout threshold, the marginal value increases towards its face value. More precisely, the precautionary benefit of an additional dollar of cash decreases at a slower rate than its opportunity cost for high levels of cash, resulting in this dollar being valued more than the previous one added in the cash account. This feature differs from the monotonically decreasing marginal value of cash in previous agency-free contributions (Bolton et al., 2011; Décamps et al., 2011) and yields a novel empirical implication indicating a scope for polynomial tests when it comes to cash holding valuation.

Finally, it is worth noticing that the marginal value of cash increases for very low levels of cash with the introduction of the self-interested manager.[17] This feature of our model indicates that the effect on the market value of cash of introducing the self-interested manager is not uniform across all levels of cash. Most notably, low cash balances in firms suffering from higher managerial entrenchment may be valued higher than similar reserves in firms with less entrenched managers.

4.2. Comparative statics of cash management policies

Having discussed the overall impact of our framework, we now turn to studying the separate effects of the model's parameters on cash policies and values. We extend the results to testable implications by expressing the same features as a ratio of firm value, a proxy of which (cash over book value) is typically used in related empirical research.

[17] This effect is due to the lumpy resetting of the cash balance upon hitting the refinancing barrier ($\underline{C} = 0$). The reader can check that in a model where restocking is incremental, the marginal value of cash decreases throughout the entire range of cash levels.

4.2.1. Managerial entrenchment

Panel (a) of Figure 2 illustrates further the effect of managerial entrenchment on cash policies. As the value of the shareholder's outside option decreases (an increase in γ), the manager becomes more irreplaceable and can extract more rents from her decision-making position over time, for example, through an overall overinvestment in negative NPV projects (empire-building). In our framework, this translates into a delayed dividend payout (higher $\overline{C}$), which leads to mostly lower marginal values of cash, that is, the value of an additional dollar held inside the firm drops. This drop in value results in fewer proceeds from equity issuances (lower $\tilde{C}$).[18]

[Please insert Figure 2 about here]

The graph illustrates that an increase in the cost of managerial replacement results in an increase in the wedge between refinancing ($\widetilde{C}$) and payout ($\overline{C}$) levels, and hence a longer expected time until payout after an equity issuance has taken place. This divergence of the two threshold levels resembles (qualitatively) the effect that an increase in the proportional cost of issuance $(p-1)$ would have on cash policy, as depicted in Panel (b) of Figure 2. Due to this feature, cash management models use proportional cost of issuance parameters as a reduced-form proxy of adverse selection problems to replicate the time lag between financing and payout observed in real data. In fact, setting the proportional cost of equity issuance to zero in an agency-free model would result in shareholders replenishing cash reserves fully (up to the payout threshold), which would imply a high probability of payout ($= 1 - \Phi\left(-\frac{\mu}{\sigma}\right)$) in the next instance. This result is highlighted by the convergence of the thresholds for the benchmark firm (dashed lines) at $p = 1$ in Panel (b) of Figure 2.

The absence of a managerial entrenchment parameter, and of its feature of generating a wedge between refinancing targets and payout thresholds, from an empirical estimation would make the proportional cost of equity issuance a dual-purpose tool. This naturally would lead to upwardly biased model estimates and render them difficult to interpret. An interesting feature of our framework is that, by incorporating a more direct measure of (perceived) agency problems, it alleviates the extra burden from the proportional cost parameter, allowing it to reflect purely the marginal cost incurred from issuing one extra dollar of equity. As shown in Panel (b) of Figure 2, our framework does not rely on the existence of a proportional cost of equity issuance to generate a time lag between financing and payout (solid lines).

[18]Recall that when $\gamma < \underline{\gamma}$, removing the manager and acquiring the firm (the outside option) whose return on cash does not exhibit the shortfall λ becomes optimal for shareholders. Panel (a) of Figure 2 plots the effect of entrenchment for values above this threshold; for $\gamma < \underline{\gamma}$, the shareholder optimal strategy consists of determining the managerial removal policy outlined at the end of Section 3.

4.2.2. Cash return shortfall

A slower cash accumulation, due to either market imperfections or agency problems, results unarguably in lower firm values since a larger proportion of liquid assets is lost per unit of time. As a dollar of cash becomes more valuable outside the firm for high levels of cash, an earlier payout is optimal. This result is depicted by the drop in the payout threshold of the agency-free firm $\overline{C}^L$ (dotted line) in Panel (a) of Figure 3. The graph also illustrates that the payout threshold drops for the firm run by the self-interested manager too upon the deceleration of the cash reserve build-up. What differs between the impact of the cash depleting factor on the two firms' cash policy is the rate of change in the payout threshold, but also the direction of the effect on the resetting target.

[Please insert Figure 3 about here]

Looking into the effect on the payout threshold, one can notice that an increase in the cash return shortfall λ leads to a decrease in value of both the manager-led and agency-free firms. However, because of managerial entrenchment, the former is expected to hold a higher quantity of cash and hence loses more value than the latter. As the shareholders' outside option is unaffected by a change in this parameter, the wedge between firm value and outside option shrinks and the manager is forced to pay out earlier in order to maintain her position. Indicatively, an increase in λ from 1.5% (baseline value) to 2.5% leads to a drop in the payout threshold from 16.9% to 11.5%, when the respective agency-free figures are 6.5% and 5.8%.

Turning to the refinancing target, Panel (b) of Figure 3 shows that a deceleration in the cash accumulation results in lower cash injections from shareholders into the benchmark agency-free firm (dashed line). A higher proportion of cash being wasted when held into corporate reserves, makes shareholders reluctant to invest as much into the firm's activities. In the case of the firm run by the self-interested manager though (solid line), this effect is mitigated by the ensuing earlier payouts as discussed above, leading to an increase in the amount of equity proceeds collected upon refinancing.

Examining the effect of an increase in λ explains the latter result further. Incorporating agency considerations unveils a dual effect of λ on the value of cash. In models considering only optimal liquidity policy, higher tunneling activity reduces the value of cash. This *direct* effect simulates the moral hazard problem in information asymmetry environments à la Jensen (1986). Nevertheless, in a model allowing for deviations from payout optimality, higher tunneling activity also decreases the marginal contribution of the manager to firm value, forcing earlier payouts. This *indirect* effect yields higher values of cash.

Figure 4 depicts the change in the marginal values of cash for the agency-free firm (ΔV_C^L, dashed line) and for the firm run by the self-interested manager (ΔV_C, solid line) after a 1% increase (from 0.01 to 0.02) in λ. As in traditional cash management models, an increase in the cost of carrying cash leads more commonly to lower marginal values of cash in the agency-free case. This is true for the largest portion of the negatively skewed cash holdings distribution, but the opposite holds close to refinancing due to the lumpy restocking of liquid assets.

[Please insert Figure 4 about here]

One would expect that an increase in the cash return shortfall would have a far more pronounced impact on marginal cash values for the firm run by the self-interested manager, since the payout in that case occurs at suboptimally high levels of cash. This would indeed be the case if the change did not alter the cash management of the firm; yet, recall that, at the same time, an increase in λ for the manager-led firm leads to a drop in the payout threshold as shareholders want to cash out earlier to compensate for the loss in the speed of accumulation inside the firm. This payout acceleration also affects (positively) the marginal cash value and this latter effect dominates the former, leading to an increase in the marginal value of cash almost throughout the entire support of cash levels.

Jointly, the results above leads to novel implications for corporate governance policies. Tightening the monitoring of managerial actions (i.e., lowering λ for the manager-led firm) would result in less corporate resources being wasted on unprofitable projects per dollar of cash. However, an extra dollar of cash may contribute less on average to bridging the gap until payout as the manager would still try to cash in as much of her comparative advantage by hoarding more resources within her reach. This latter effect dominates the former, leading to a decrease in the value of cash. At the same time, adding credibility to an irreversible replacement threat (i.e., decreasing γ) acts as a disciplining mechanism forcing the manager to self-restrict her tunneling activity through earlier payouts.[19] Consequently, the relative contribution of an extra dollar of cash to the reduction of the time until payout, and hence its value, increases.

4.2.3. Productivity and economy-wide parameters

Regarding the remaining parameters of our framework, their effects on the corporate liquidity policy and the ensuing predictions are in line with those of previous cash management models (e.g., Décamps et al.

[19] In a way similar to a manager's choice of debt issuance as a voluntary self-constraint in Zwiebel's (1996) capital structure model. We discuss an extension of our model for debt financing in Section 6.2.

2011). The payout threshold is decreasing in the firm's ability to generate cash flows (μ) and the marginal cost of equity issuance (p), but increasing in the volatility of cash flows (σ), the fixed cost of refinancing (ϕ), and the risk-free rate (r). With the exception of the diverging effect of p discussed in Section 4.2.1, the change in the equity issuance target ratio following the change in one of the parameters above qualitatively parallels the effect on the payout threshold.

5. Risk management

In this section, we discuss how the different claimants (shareholders and the manager) would behave if faced with the opportunity to manage the riskiness of the firm's cash flows.

5.1. Risk preferences of shareholders and the manager

As pointed out in Proposition 1, the value to shareholders is concave when cash reserves are low (from 0 to C^*) and convex when cash reserves are high (from C^* to $\overline{C}$). This implies that shareholders prefer to adopt risk-decreasing strategies in low states and higher-risk strategies in high states of the cash variable. Intuitively, shareholders would like to reduce cash flow volatility when the likelihood of incurring issuance costs is higher and the cost of holding cash ($\lambda\, C$) is low, that is, close to refinancing. However, as cash increases and the probability of running out of cash decreases, the cost from the manager's tunneling activities grows and considerably delays payout. Hence, at high levels of cash, it is more beneficial for shareholders to maintain (or even increase) cash flow volatility: a positive shock would lead to earlier payout, while a negative outcome would be mitigated by a reduction of the cash return shortfall from tunneling.

Nonetheless, this strategy would be implemented only if the control rights of the firm's risk management policy lay with shareholders. If, however, the latter were to be delegated to the manager, the risk strategy of the firm would differ. In order to determine the manager's risk incentives, one needs to characterize her value function, which we denote by $M\,(c)$. It satisfies the following equation:

$$M\,(C_t) = \theta\, C_t\, \Delta t + e^{-r\,\Delta t}\, \mathbb{E}_t\left[M\,(C_{t+\Delta t})\right], \tag{23}$$

which leads to the ODE:

$$\frac{1}{2}\,\sigma^2\, M_{CC} + \left[\mu + (r-\lambda)\, C\right]\, M_C - r\, M + \lambda\, C = 0. \tag{24}$$

ODE (24) is subject to two conditions stemming from our setup. The first one reflects that incremental payout occurs at $\overline{C}$; at this point, adding a unit of cash returns no additional value to the manager as the entire unit is paid out as dividend to shareholders. Hence,

$$M_C\left(\overline{C}\right) = 0 \tag{25}$$

The second condition relates to refinancing. As soon as the firm runs out of cash, the reserves are replenished up to $\tilde{C}$ and the manager's value function satisfies

$$M(0) = M(\tilde{C}) \tag{26}$$

Combining these two conditions with the ODE (24) yields the following proposition.

Proposition 2. *For a firm facing equity issuance costs and run by a sufficiently entrenched self-serving manager, it holds that*

1. *The value to the firm's manager, $M(c)$, is U-shaped with respect to cash stock c, that is, decreasing in $\left[0, \hat{C}\right)$ and increasing in $\left(\hat{C}, \overline{C}\right)$*
2. *$M(c)$ is convex for $c \in \left[0, C^M\right)$ and concave for $c \in \left(C^M, \overline{C}\right]$, where $\hat{C} < C^M < \overline{C}$.*

Proposition 2 reveals the risk preferences of the manager with respect to the level of cash holdings. For low levels of cash, the manager benefits from relatively high volatility of cash flows as hitting the downward bound of cash reserves results in a costless (from her perspective) refinancing and, hence, an upward jump in her payout. For high levels of cash, the manager's return from tunneling activities approaches its upward bound (achieved at the payout threshold) and increases her willingness to reduce the probability of low states reoccurring. Hence, in case the risk management strategy is delegated to the firm's manager, she would be more likely to refrain from risk-reducing activities when cash reserves are low (i.e., for $C \in \left(0, C^M\right)$) and undertake them when the cash balance is high ($C \in \left(C^M, \overline{C}\right)$).

Figure 5 summarizes the shareholder-manager conflict on the corporate risk management strategy arising from the analysis above. Shareholders are willing to decrease the firm's risk when cash holdings lie in $(0, C^*)$ and leave it unchanged (or even increase it) for cash levels in $\left(C^*, \overline{C}\right)$; while managers prefer to increase the firm's cash flow risk when cash holdings lie in $\left(0, C^M\right)$ and conversely for cash levels in $\left(C^M, \overline{C}\right)$. Hence, there are conflicting preferences among the two parties towards the boundaries of the no-payout region and different risk management strategies could be adopted depending on the allocation of control rights.

[Please insert Figure 5 about here]

In the case where the riskiness of cash flows lies within managerial control, our framework reflects two noted agency conflicts with respect to risk taking. At the lower end of the cash support, the restricted opportunities for tunneling and the lumpy refinancing may lead an entrenched manager to increase the firm's cash flow riskiness at the detriment of shareholders' preferences. Outside our model, a propensity to maintain high cash flow risk would weaken the relation between risk and required return in the decision-making process of a firm and resemble the biased undertaking of negative-NPV projects, as attributed to managerial hubris (Roll, 1986). At the higher end of the support, the increased perks and the upper bound of cash reserves being set at the payout threshold may induce the manager to take risk-reducing actions although shareholders would be better off with higher cash flow volatility. In a real-life setting, this reluctance for risk-taking could be manifested as managerial slack hindering firm value maximization, in line with Hicks' (1935) "quiet life".[20]

Interestingly, conflicts regarding the risk management strategy of the firm do not occur throughout the full range of possible cash levels. In fact, this is the case towards the center of the no-payout region where an alignment of the risk preferences of both parties could occur, that is, if $C^* \neq C^M$. For instance, a positive (negative) difference of the expression $\left(C^* - C^M\right)$ would mean that a lower (higher) exposure to cash flow risk may be benefiting both parties; in the case where $C^* = C^M$, there is disagreement on the risk management policies across the entire range $\left[0, \overline{C}\right]$.

In Figure 6, we plot the switching points in the risk preferences, that is, the inflection points of the respective value functions, of shareholders (C^*) and management (C^M) against the parameters of main interest, γ and θ. Given that shareholders would prefer to reduce cash flow risk for cash levels lower than C^* and maintain (or increase) its risk otherwise, and that management would gain from reducing cash flow risk for cash levels above C^M and increase risk otherwise, the shaded area in both sides of the panel indicates the range of cash levels for which both parties would benefit from the lower cash flow riskiness. To illustrate the portion of the stationary distribution of cash as a proxy of the likelihood of the risk preferences of shareholders and manager being aligned, both thresholds are scaled by the payout threshold $\overline{C}$.

It is worthwhile to note that the resulting predictions vary depending on the allocation of the control rights. If the risk management decision is made by shareholders (the manager), the propensity for reducing cash flow risk decreases (increases) with managerial entrenchment, but increases (decreases) with tunneling. Looking at the particular case where the two parties have to collectively agree on the risk management strategy, panel (a) shows that, as γ increases, the two thresholds not only approach zero, but also converge, that is, the portion of the cash distribution in which risk-reducing actions are undertaken is narrower.[21]

[20] Using Bertrand and Mullainathan's (2003) interpretation of managers avoiding "difficult decisions and costly efforts" associated to the opening and closure of plants, the manager's aversion for risk at high levels of cash capacity would push wider the thresholds triggering these decisions.

[21] Note that although the distribution of cash is not uniform, it is negatively skewed for all parameter values examined in this study with the mode being at the truncation (payout) threshold. Hence, the probability density function increases with the level of cash.

Conversely, panel (b) reveals that both thresholds approach the payout threshold as θ increases, but at different rates such that the range of values for which hedging would occur is wider.

[Please insert Figure 6 about here]

5.2. Optimal hedging strategies of shareholders and the manager

To formalize the optimal hedging strategies of the two parties, we introduce a futures contract whose price f_t is a function of a Brownian motion positively correlated with the process (1), which governs the firm's cash flows (cf. Babenko and Tserlukevich, 2020). The dynamics of the hedging asset price is

$$df_t = \varsigma dB_t, \tag{27}$$

where ς is its volatility, dB_t is a Wiener increment with $E\left[dB_t dW_t\right] = \rho$ denoting the correlation between returns of the hedging instrument and the firm's cash flow. In general, there is a proportional cost $\kappa \geq 0$ of hedging with asset f. We denote the hedge ratio chosen by the holder of claim $F \in \{M, V\}$ by h^F and the instantaneous payoff to that claim by π^F. Given the cash balance C, the value of claim F satisfies the following Hamilton-Jacobi-Bellman equation

$$rF(C) = \max_{h^F \geq 0} \left\{ \left[\mu + \left(r - \lambda - \kappa h^F\right) C\right] \frac{\partial F}{\partial C} + \frac{\tilde{\sigma}^2(h^F)}{2} \frac{\partial^2 F}{\partial C^2} + \pi^F(C) \right\}, \tag{28}$$

where

$$\tilde{\sigma}(h^F) \equiv \sqrt{\sigma^2 + \left(h^F\right)^2 \varsigma^2 - 2h^F \rho\sigma\varsigma}. \tag{29}$$

Solving the (intertemporal) maximization problem (28) yields the optimal risk management policy for the holder of claim F:

$$h^F = \begin{cases} \max\left\{h_0 - \frac{\kappa C F_C}{\varsigma^2 |F_{CC}|}, 0\right\} & F_{CC} < 0, \\ 0 & \text{otherwise,} \end{cases} \tag{30}$$

where $h_0 \equiv \frac{\rho\sigma}{\varsigma}$ is the frictionless optimal hedge ratio when the value function is concave ($F_{CC} < 0$).[22] Substituting back the optimal hedge ratio (30) to (28) leads to the following dynamics of claim F:

$$rF(C) = \left[\mu + \left(r - \lambda - \psi(h^F)\kappa h_0\right) C\right] F_C + \frac{\left(1 - \psi(h^F)\rho^2\right) \sigma^2}{2} F_{CC} - \frac{\psi(h^F)\kappa^2 C^2 F_C^2}{\varsigma^2 F_{CC}} + \pi^F(C), \tag{31}$$

where $\psi(h^F)$ is defined as 1 for $h^F > 0$ and 0 otherwise (i.e., when the hedging instrument is optimally not used). From (31) it can be seen that hedging affects the dynamics of the claim value through three channels.

[22] The second-order condition is satisfied for $F_{CC} < 0$.

First, it negatively affects the drift rate due to the proportional cost parameter κ. Second, it reduces the effective standard deviation of the cash flow process. Finally, there is an additional effect of the anticipated variation of the hedge ratio and the associated cost, as the claim curvature changes with C, which is captured by the third component.

When hedging is frictionless, which we assume in the remainder of this section, (31) simplifies to

$$rF(C) = \left[\mu + (r-\lambda)\,C\right] F_C + \frac{\left(1-\psi(h^F)\rho^2\right)\sigma^2}{2} F_{CC} + \pi^F(C). \tag{32}$$

Hedging is therefore equivalent to lowering the standard deviation of the firm's cash flows (from σ to $\sqrt{1-\rho^2}\sigma$).[23]

As already discussed, the shareholders' value function V is generally concave for relatively low levels of cash (where higher volatility increases to probability of costly refinancing) and convex for its high level (where higher volatility generally leads to a more likely payout). Therefore, we conjecture that shareholders would be willing to engage in risk management activities for C below a certain threshold $C_h \in \left(\tilde{C}, \bar{C}\right)$ and keep volatility unchanged for $C \in \left(C_h, \bar{C}\right)$.

To find a solution to the shareholders' risk management problem, one needs to solve ODE (32) subject to boundary conditions (15) and (17)–(19) as well as:

$$\lim_{C\uparrow C_h} V = \lim_{C\downarrow C_h} V, \tag{33}$$

$$\lim_{C\uparrow C_h} V_C = \lim_{C\downarrow C_h} V_C, \tag{34}$$

$$\lim_{C\uparrow C_h} V_{CC} = \lim_{C\downarrow C_h} V_{CC} = 0. \tag{35}$$

Conditions (33) and (34) ensure continuity and differentiability of shareholders' value function at the reversible threshold C_h, with condition (35) being the optimality condition for C_h.

Assuming that the risk management decision is delegated to the manager, the problem can be solved in a similar way to that above. The key difference between the problem of the manager and that of shareholders is that the value of the claim of the former is convex for *low* C and concave otherwise. In addition, while the manager decides on the risk management strategy, the choice of refinancing policy is made by shareholders, the valuation of whose claim also indirectly determines the payout policy. Therefore, the solution of the manager's problem obtained by jointly solving equation (16) for $V(C)$ and $M(C)$, subject to boundary

[23] Introducing the cost of hedging inevitably results in less hedging and a possible occurrence of additional non-hedging regions when cost parameter κ is sufficiently high. As insights offered by such a generalization do not appear to outweigh the additional complexity that costly hedging would introduce, we restrict our analysis to the case of $\kappa = 0$.

conditions (15), (17)–(19), (33) and (34) as well as:

$$\lim_{C\uparrow C_h} M = \lim_{C\downarrow C_h} M, \tag{36}$$

$$\lim_{C\uparrow C_h} M_C = \lim_{C\downarrow C_h} M_C, \tag{37}$$

$$\lim_{C\uparrow C_h} M_{CC} = \lim_{C\downarrow C_h} M_{CC} = 0. \tag{38}$$

Conditions (36) and (37) ensure continuity and differentiability of the managerial value function at the reversible threshold C_h, with condition (38) being her optimality condition for C_h.

5.3. Discussion

Equipped with the solution of the risk management problem, we jointly obtain the claim values as well as hedging, refinancing and payout policies for both cases – those of shareholders and the manager controlling the risk management policy. In Figure 7 we depict both sets of policies (i.e., with shareholders and the manager choosing C_h to maximize the value of their respective claims) as a function of the correlation of the hedging instrument with the firm's cash flow, ρ ($\rho = 0$ corresponds to the original set-up, where hedging is not possible). If it is shareholders who control the risk management policy, they trade off the expected cost of refinancing with the present value of payout, which occurs when cash balance is sufficiently high. As discussed, the risk of the firm's cash flow is hedged for $C \in \left(0, C_h^{(s)}\right)$ and left unchanged otherwise. A higher correlation coefficient ρ has two key effects on shareholders' policies. First, it reduces the amount of new financing $\tilde{C}$ that shareholders raise when cash balance hits zero. This outcome is intuitive, as the "target" cash balance can be lower if cash flow is less risky. Second, the region $\left(0, C_h^{(s)}\right)$, in which shareholders hedge, shrinks. The latter effect is due to the fact that when hedging becomes more effective, it needs to be applied for a smaller range of cash balance to manage the risk of costly refinancing.[24] Finally, the effectiveness of the hedging instrument has a negligible effect on the payout threshold $\bar{C}^{(s)}$. The reason for the absence of a significant effect here is that hedging occurs for low cash balances only. As a result, for high cash balances, it does not materially affect the firm value and, hence, its intersection (net of the managerial replacement cost) with the value of the shareholders' outside option.

The previous assumption that shareholders choose the risk management policy of the firm is made mainly to allow for the comparison between the two cases. In practice, it is the manager who predominantly has discretion over the riskiness of corporate cash flows. As managing operational risk can in principle be

[24] In the limit, i.e., when $\rho \to 1$, both $\tilde{C}^{(s)}$ and $C_h^{(s)}$ tend to zero. The ability to switch off the variance of the cash flow process completely allows for avoiding costly refinancing due to the positive drift rate μ, even if the variance is removed exactly when cash balance reaches zero from above. In the limiting case, conditions (18) and (19) are replaced by a single condition $V_C(0) = 0$, as zero effectively becomes a reflecting barrier in such a case.

implemented though a sequence of tactical investment and production decisions, shareholder approval may not be needed at all to affect the level of cash flow volatility. Also financial risk management decisions generally do not require shareholder approval as they lie within the domain of the firm's management. Therefore, the results of the variant of the model in which the manager decides when to hedge are likely to offer more reliable testable predictions of corporate policies as well as implications for the firm valuation.

When it is the manager who controls the risk management policy, the situation is diametrically different. When deciding to reduce the risk, the manager trades off the benefit of a lower likelihood of reducing the cash balance (which would reduce her tunneling opportunities) with less frequent replenishment of cash, conditional of its level being relatively low. Therefore, the optimal policy of the manager is to reduce risk for relatively high cash levels, that is $C \in \left(C_h^{(m)}, \bar{C}^{(m)}\right)$, and leave cash flow volatility unchanged otherwise. One can see from Figure 7 that the managerial hedging policy ($C_h^{(m)}$) is not sensitive to the effectiveness of hedging instrument (ρ), as relevant present values are affected by cash flow volatility to a similar degree. Given that the region where hedging does not occur is not materially affected by the level of ρ, neither is the shareholders' refinancing policy $\tilde{C}^{(m)}$. What changes significantly with higher effectiveness of the hedging instrument (ρ) is the level of the payout threshold $\bar{C}^{(m)}$. Lower cash flow volatility for the relatively high cash balance results in the retention of the manager being less attractive for shareholders, which translates into a negative relationship between ρ and $\bar{C}^{(m)}$.

[Please insert Figure 7 about here]

Finally, the magnitude of the correlation between the firm's cash flow and the price of the hedging asset affects the range of cash balances at which risk incentives of the managers and the shareholders agree. As it has already been shown in Figure 5, the region of managerial preference for "quiet life" ($C > C^M$, which is the limit of $C_h^{(m)}$ for $\rho = 0$) partially overlaps with the range of C for which shareholders prefer lower risk as well ($C < C^*$, which is the limiting case of $C_h^{(s)}$). However, the situation may change once the possibility of (effective) hedging actually arises. As it can be seen on Figure 7, the region of aligned preferences for hedging (i.e., $C \in \left(C_h^{(m)}, C_h^{(s)}\right)$) shrinks with ρ. There exists a critical level of ρ (ρ^*) at which $C_h^{(m)} = C_h^{(s)}$ and shareholders' preferences for hedging are exactly opposite to that of the manager. Beyond ρ^*, there exists a range $C \in \left(C_h^{(s)}, C_h^{(m)}\right)$ in which the region of managerial "hubris" overlaps with areas of shareholders' preference for higher risk and where shareholders and the manager are in agreement *not* to hedge.

The results of the analysis above are best summarized in the form of empirically testable implications. First, *all else equal*, different risk management activities can occur throughout the range of a firm's cash levels. In the case where the risk management policy needs to be collectively decided between shareholders and the manager, risk management activities may have a hump-shaped relation to cash reserves; that is, the firm engages in risk-management strategies for moderate levels of cash but not in the proximity of refinancing- or payout-triggering levels. This prediction deviates from the traditional view of substitutability between liquidity and risk management (e.g., Bolton et al., 2011) as in our model these policies result from an interplay between the manager's and shareholders' preferences. Contrary to the common assumption of managerial risk-aversion (Stulz, 1984; Smith and Stulz, 1985), the manager in our model is entrenched enough to be willing to engage in risk-increasing activities at low values of cash.[25] However, since such a policy would not be ratified by shareholders, this risk-shifting propensity will not materialize leading to the hump-shaped relation described above.

The model also yields predictions regarding the relation between risk management policies and agency considerations. In particular, risk-reducing activities are increasing in tunneling, or more generally, and consistently with previous literature (e.g., DeMarzo and Duffie, 1991; Breeden and Viswanathan, 1998; DaDalt, Gay, and Nam, 2002), hedging is increasing in information asymmetry. Recall that the marginal value of a dollar of cash decreases with the effectiveness of monitoring. This reflects the fact that holding cash becomes more costly for shareholders, which naturally reduces their incentives for risk management. Furthermore, the model predicts that firms operated by more entrenched managers will engage less often in risk-reducing activities. Similar to the argument above, the associated drop in the marginal value of cash increases the risk tolerance of shareholders and reduces their propensity to hedge.

Regarding the empirical testing of the above predictions, one needs to notice that two manifestations of poor (good) corporate governance, more (less) tunneling and high (low) managerial entrenchment, have conflicting effects on the firm's propensity for risk-reducing actions. Hence, outcomes of empirical tests involving aggregate measures of corporate governance can very well be mixed. In this light, it comes as little surprise that empirical evidence on the effects of corporate governance on hedging is inconclusive.[26] Moreover, these two aspects of corporate governance can be significantly correlated to each other and both are shown here to affect risk preferences; hence, unless both are adequately controlled for in an empirical specification, results are prone to omitted variable biases. Finally, note that an omission of either tunneling and managerial entrenchment would violate the *ceteris paribus* clause of the U-shaped relation between risk-taking and cash levels. Given that these are driving both cash levels and risk preferences, such an omission could yield a biased empirical result of complementarity between liquidity and risk management policies.

[25]Still, our model is able to generate such a managerial risk-aversion unrelated to cash levels in the presence of risky debt (see Section 6.2.1) which, similar to the case of a poorly entrenched manager, may lead to unavoidable managerial removal when cash reserves are depleted. Under such a scenario, the manager of our model would consistently prefer to hedge, if she could.

[26]See Aretz and Bartram (2010) for a comprehensive review of the empirical literature.

6. Extensions

Our analysis has focused so far on the broad range of implications of partial delegation of corporate cash management to a self-interested manager. Admittedly, and for the sake of tractability and comparability with the extant literature, a number of simplifying assumptions, in particular regarding the lack of explicit investment and capital structure policies, have been introduced. To investigate what effect the relaxation of some of the assumptions would have on refinancing and managerial payout policies, we present below an extension for the presence of an investment opportunity, followed by a discussion of the implications of debt financing. We conclude the section with the analysis of the managerial problem under the threat of shareholder activism.

6.1. Investment opportunity

In this section, we modify our model to examine investment considerations. In particular, we extend our main framework by endowing our manager-led firm with an investment opportunity and analyze the implications on corporate investment decisions as well as the effect of said opportunity on current cash policies. We retain the basic set of parameter values for any numerical illustrations.

6.1.1. Setup

At time $t = 0$, a firm run by a self-interested manager expects to acquire a single opportunity to invest, which arrives with a Poisson rate η. If undertaken upon arrival, at time $t = \tau^I$, the investment increases firm profitability μ by $\Delta\mu$ (and its cash flow volatility σ by $\Delta\sigma$ respectively, such that $\frac{\mu+\Delta\mu}{\sigma+\Delta\sigma} = \frac{\mu}{\sigma}$). The irreversible investment cost is k and the opportunity expires shortly after its arrival, such that the manager faces a now-or-never investment decision.

Although the decision is taken by the manager, it is subject to shareholders' decision rights. These consist of a) denying an extraordinary equity issuance to finance the investment if the cost of financing exceeds the corresponding increase in firm value (i.e., shareholders' share of the investment's NPV); and b) rejecting the manager's decision to invest if the value of their outside option is higher than the value of their share in the manager-run firm upon investment, by exercising their option to replace the manager before the completion of the investment (and the outflow of k).[27] Decision rights on cash policy remain identical to our base-case model, i.e., the manager implements the payout policy, whereas shareholders choose the equity amount to be issued when the firm's cash reserves are depleted.

[27] If shareholders could remove the manager only when the investment cost is sunk, the range of parameter values for which investment is undertaken would expand.

The investment opportunity affects managerial entrenchment in two ways. First, it increases the cost of replacing the manager *ex post*, since $\gamma V_{\lambda=0}^{L,I}(0) > \gamma V_{\lambda=0}^{L}(0)$, where $V^{L,I}(C)$ represents the value of the firm if run by shareholders after investment has taken place (from now on, we use superscript I to denote a post-investment quantity). This reflects a situation where the manager has access to and invests in manager-specific projects that add to her irreplaceability, as in Shleifer and Vishny (1989). Second, the probability of a positive-NPV investment opportunity generally affects the cost of replacing the manager also *ex ante*, as its arrival is conditional on the firm being run by the manager. The latter assumption recognizes that market awareness, including the ability to spot investment opportunities, is an important part of a manager's skill set and one of the reasons why managers are typically granted a degree of discretion over corporate investment decisions. While these assumptions generally enable the manager to capture a large part of the investment's NPV by delaying payout to shareholders, they also allow for cases where the payout threshold drops below that of the no-investment base case.

6.1.2. Investment decision

Since the effect of the investment prospect on cash holdings at $t = 0$ depends on future (investment and cash management) decisions, we begin our analysis by determining the cash policy of the manager-led and shareholder-run firms once the investment opportunity has either been exercised or elapsed, with the latter case corresponding to the base case of Section 2.[28] Once the cash policy after the investment decision is known, we can turn to the investment decision itself, i.e., whether the firm will disburse k at $t = \tau^I$ for its profitability to increase by $\Delta\mu$. In our setup, where the investment decision leads to a considerably higher payout threshold, the manager is to a large extent trading off a temporary setback in her tunneling with an increased tunneling potential due to a higher speed of cash accumulation. Following extensive checks for a broad range of parameter values, our analysis indicates that the positive effect of investment on the difference between $\overline{C}^I$ and $\overline{C}$, coupled with the increase in μ, dominates the effect of the instantaneous drop of the manager's tunneling flow by λk, so that the manager is always in favor of undertaking the investment.

Still, this is not the case for shareholders, for whom the optimality of the investment decision depends not only on the initial outlay k, but also on the level of cash in corporate reserves at the time of the investment opportunity's arrival, C_{τ^I}. The investment policy of the manager-led firm is depicted in Figure 8 which plots the break-even investment cost $\bar{k}$ at the time of the decision. The x-axis represents the level of cash reserves at the time of arrival, while the y-axis represents the initial outlay k. The white area reflects the range

[28]Due to the cost of managerial replacement increasing with investment, the payout threshold increases with newly installed capital, i.e. $\overline{C}^I > \overline{C}$. Indicatively, a project increasing μ from 0.18 to 0.20 results in a payout threshold of 0.9531 after investment has taken place, in contrast to just 0.8576 if investment has not been implemented. As a validation check, the cash ratios at payout are very close to each other (both equal to 0.1693 with four-digit precision), confirming that the *ex-post* relative cost of replacement is unaffected by the investment decision.

of values for which investment takes place, while the shaded area denotes the no-investment region. Note that the frictionless NPV of this investment opportunity is $\frac{\Delta\mu}{r} - k$ and the black dotted line at $k = 0.50$ represents the break-even investment cost for an increase in profitability of $\Delta\mu = 0.02$ (given that $r = 0.05$).

[Please insert Figure 8 about here]

Turning to the decision of the manager-led firm, we first observe that the firm will invest regardless of cash levels for $k < 0.446$, meaning that the fraction of the NPV captured by shareholders always exceeds the initial investment cost in that region. For higher cost levels, shareholders exercise their right to deny a new equity issuance for investing in the project, for some range of cash if $k \in (0.446, 0.463)$, or for all levels of cash $C_{\tau^I} < k$ if $k \in (0.463, 0.4675)$. In either subregion, shareholders are unwilling to issue new equity as the issuance cost exceeds the gain in value from investing; that is

$$\phi + p\left(\widetilde{C}^I + k - C_{\tau^I}\right) > V^I\left(\widetilde{C}^I\right) - V\left(C_{\tau^I}\right),$$

where $\widetilde{C}^I$ is the target cash balance upon refinancing after the new investment is in place. Shareholders' reluctance to issue new equity is more pronounced for cash balances close to 0.114, a range that widens as the cost of investment increases. This is because the value of the cash balance, which is going to be fully spent on the investment, is at its peak for this level of accumulated cash (see also Panel *b* of Figure 1). For lower cash balances shareholders may be inclined to issue to invest as refinancing is still very likely even if they do not, while for higher levels of cash, both the average value of already accumulated cash and the variable costs of issuance are lower.

For $k > 0.4765$, the second option of shareholders, the one that allows them to replace the manager if she attempts to undertake the project while their outside option without the investment is more valuable, may be triggered. It will be exercised when

$$V\left(C_{\tau^I}\right) > V^I\left(C_{\tau^I} - k\right)$$

As the NPV of the project drops, the value accruing to shareholders is too low to justify the expenditure of valuable cash and they are better off sacrificing a low NPV project to avoid refinancing or benefit from an earlier payout. Shareholders are more prone to allowing the investment to take place when the average cash value spent is at its lowest, i.e., for cash balances in the region of 0.65.

Finally, there is a substantial underinvestment region as a consequence of agency problems, relative to not only the frictionless break-even investment cost benchmark of $k = 0.5$, but also to that of a shareholder-run ($\gamma = \lambda = 0$) having access to the same investment opportunity (dashed line in Figure 8).

6.1.3. Cash management decisions at $t = 0$

As a final step, we examine the cash policy decisions taken at $t = 0$, i.e. in expectation of the investment opportunity to arrive in the future (with an instantaneous rate of arrival equal to $\eta\, dt$). To do so, we need to identify the possible regions of the state variable (C) and solve for the ordinary differential equations of shareholder value for each region. Based on our analysis in the previous section, there are three regions in which the state variable may be at any point in time: i) a region where refinancing is required (and ratified by shareholders) so that investment takes place if the opportunity arises, ii) a region where investment takes place if the opportunity arises without the need for refinancing (and with shareholders not triggering the managerial replacement option), and iii) a no-investment region as set by shareholders' optimal exercise of their options. The three regions are depicted in Figure 8.

The ODE for shareholder value for each region j, V^j, can be written as

$$\frac{1}{2}\sigma^2 V^i_{CC}\left(C\right) + \left[\mu + \left(r-\lambda\right)C\right] V^i_C\left(C\right) - \left(r+\eta\right) V^i\left(C\right) + \\ +\eta\left[V^I\left(\widetilde{C}^I\right) - p\left(\widetilde{C}^I + k - C\right) - \phi\right] = 0, \quad (39)$$

$$\frac{1}{2}\sigma^2 V^{ii}_{CC}(C) + [\mu + (r-\lambda)C]V^{ii}_C(C) - (r+\eta)V^{ii}(C) + \eta V^I\left(C-k\right) = 0, \quad (40)$$

$$\frac{1}{2}\sigma^2 V^{iii}_{CC}(C) + [\mu + (r-\lambda)C]V^{iii}_C(C) - (r+\eta)V^{iii}(C) + \eta V\left(C\right) = 0, \quad (41)$$

with the latter equation simply implying that $V^{iii}(C) = V(C)$ (of the baseline model). For each level of k, we identify the (no-)investment regions involved and piece the resulting value functions together using value-matching and smooth-pasting conditions at intersection points ($\bar{k}$ and/or k). The solution is completed with the conditions that determine the firm's cash policy at $t = 0$. For instance, for $k = 0.46$, shareholders' value before investment is a piecewise function consisting of three regions:

$$V_0(C;k) = \begin{cases} V^{iii}(C) & C \in (0,\bar{k}) \\ V^i(C) & C \in (\bar{k},k) \\ V^{ii}(C) & C \in (k,\overline{C}) \end{cases}. \quad (42)$$

The relevant value-matching and smooth-pasting conditions are

$$V^{iii}(\bar{k}) = V^i(\bar{k}) \quad (43)$$

$$V^{iii}_C(\bar{k}) = V^i_C(\bar{k}) \quad (44)$$

$$V^i(k) = V^{ii}(k) \quad (45)$$

$$V^i_C(k) = V^{ii}_C(k) \quad (46)$$

while the cash policy conditions are

$$V^{iii}(0) = V_0(\widetilde{C}) - p\,\widetilde{C} - \phi \tag{47}$$

$$\left.\frac{\partial V_0}{\partial C}\right|_{C=\widetilde{C}} = p \tag{48}$$

$$V_C^{ii}(\overline{C}) = 1 \tag{49}$$

$$\overline{C} = \arg\max_{\overline{C}} \left[M(\overline{C})\right] \tag{50}$$

We use the last condition (50) instead of directly equating the firm value function with the value of shareholders' outside option to reflect the possibility that the manager could be better off by temporarily paying out earlier (at a lower threshold) than what would exhaust shareholders' tolerance if this increases the chances of the investment being undertaken in the future. Recall that in our setup, the manager is benefiting from new investment regardless of cash levels at which it is undertaken. Hence, it could be the case that for a high k the manager might want to restrict cash holdings in order to avoid the no-investment region (iii) for high balances.

To solve for condition (50), we need to determine the manager's value function and solve for the payout threshold that maximizes it. Similar to the methodology followed for shareholders' value function, the ODE for the manager's claim value for each region j, V^j, can be written as

$$\frac{1}{2}\sigma^2 M_{CC}^{i}(C) + \left[\mu + (r-\lambda)\,C\right] M_C^{i}(C) - (r+\eta)\,M^{i}(C) + \lambda C + \eta M^{I}\left(\widetilde{C}^{I}\right) = 0 \tag{51}$$

$$\frac{1}{2}\sigma^2 M_{CC}^{ii}(C) + [\mu + (r-\lambda)C]M_C^{ii}(C) - (r+\eta)M^{ii}(C) + \lambda C + \eta M^{I}(C-k) = 0 \tag{52}$$

$$\frac{1}{2}\sigma^2 M_{CC}^{iii}(C) + [\mu + (r-\lambda)C]M_C^{iii}(C) - (r+\eta)M^{iii}(C) + \lambda C + \eta M(C) = 0 \tag{53}$$

where M^I represents the value of the managerial claim if investment is undertaken at $t = \tau^I$ (and M, to which M^{iii} must be equal, is its value if the investment opportunity is rejected instead). The solution is completed with the respective value-matching and smooth-pasting conditions as well as the conditions stemming from the exercised cash policy:

$$M(0) = M(\widetilde{C}) \tag{54}$$

$$M_C(\overline{C}) = 0 \tag{55}$$

We then compute the managerial claim value for different payout thresholds (and the corresponding refinancing barrier as chosen by shareholders) in the $(\bar{k}, \overline{C}^{max})$ space, where $\overline{C}^{max}$ is the payout threshold that solves for

$$V_0(\overline{C}^{max}) = L(\overline{C}^{max}) \tag{56}$$

and select the one that maximizes the value to the manager M.

The results of our analysis are depicted in Figure 9. We first observe that the expectation of an investment opportunity arriving leads to higher payout thresholds ($\overline{C}_0$) and higher refinancing barriers ($\widetilde{C}_0$) for low investment cost values, compared to the no-investment base-case benchmarks. The increase of the former is explained by the twofold rise of the cost of managerial replacement, which allows the manager to monetize this shift of power balance by delaying payout (and hence increasing the present value of his tunneling activities). The increase of the latter is a result of the desire of shareholders to avoid having to incur refinancing costs for a second time soon after an equity issuance (if the investment opportunity arrives before the firm manages to accumulate enough cash that will position the state variable in the no-issuance investment region *ii*). This is validated by the fact that the refinancing barrier drops as soon as the cost of investment meets $\bar{k}$ (at $k = 0.446$), i.e. the first instance for which the probability of no-investment is non-zero.

[Please insert Figure 9 about here]

Our analysis also reveals that the manager may in fact select to forgo an immediate perk consumption by paying out early, in comparison to both our base case ($\overline{C}$) and the maximum payout threshold she could get away with ($\overline{C}^{max}$), in order to increase the probability that the state variable ends up in the investment region *ii* when the investment opportunity arrives. This is the case when $k \in (0.476, 0.483)$, where she ensures that cash reserves will not enter the no-investment region by setting the payout threshold to $\bar{k}$ in the hope to benefit from undertaking the investment when the opportunity arrives.[29] The increase of shareholder value resulting from earlier payouts is also reflected in the increase in the refinancing barrier for this range of k. Lastly, when the investment cost is prohibitively high for the project to be undertaken for any level of cash, the payout threshold and refinancing barrier correspond to those of the base case.

6.2. Debt financing

In this section, we extend the model to include capital structure considerations. We first examine the cash policy of a firm where debt is already in place and then proceed to the formulation of implications with respect to the debt issuance decision.

[29] At least not due to hoarding; on the other hand, our model does not provide a tool with which she could prevent cash dropping into the no-investment region due to a negative cash flow occurrence.

6.2.1. Effect of debt on cash policy

The effect of holding debt amounts to introducing debt service payments that the firm makes to debtholders as part of their outstanding contractual agreement. To simplify the analysis, we assume that the firm holds a perpetual debt contract which is serviced exclusively through continuous-time coupon payments b, so that the market value of a risk-free debt contract is equal to $B_t = \frac{b}{r}$. The corresponding cash accumulation process is expressed as

$$dC_t = dY_t - b\,dt + (r - \lambda)\,C_t\,dt + dI_t - dU_t \tag{57}$$

Shareholders' outside option is adjusted as follows: the instantaneous cash flow of the shareholder-run firm, now labeled $V^{L,B}$, is also reduced by b, which simply means that shareholders inherit the amount of outstanding debt if they opt for replacing the manager; while the cost of managerial replacement remains proportional to the enterprise value, i.e. the value of the all-equity shareholder-run firm, V^L, to reflect our assumption that capital structure does not affect the direct loss of value protecting the manager's tenure.[30]

In the presence of debt, cash accumulation slows down as the coupon reduces the instantaneous cash flow. The reduced ability to generate net cash flows leads to higher equity issuances ($\widetilde{C}$ increases with the coupon rate), but also to delayed payouts ($\overline{C}$ too increases with b) as, in relative terms, the cost of managerial replacement increases with respect to the shareholder-run firm. These effects are monotonic while debt remains risk-free.

Naturally, there exists a coupon level beyond which shareholders are unwilling to refinance the firm when cash reserves are depleted and, hence, debt is subject to default.[31] Interestingly, the default-triggering coupon level depends on the firm's cash policy. In particular, suboptimal cash policies destroy firm value and thus a firm exercising such a policy has a lower risk-free debt capacity. This is indeed the case of the manager-led firm of our model, the debt of which, based on our base case parameters, becomes risky beyond an instantaneous coupon rate of 0.169 compared to 0.172 for a firm facing the same cost of carrying cash but exercising optimal cash management. As long as the manager exhausts (or at least is expected to exhaust) the leeway of his entrenchment, any coupon rate above this threshold will result in shareholders denying refinancing the firm's operations. Even so, the additional option to default adds extra value to shareholders, which enables the manager to delay payout further, as depicted by the dashed line of Figure 10. In contrast, the manager is faced with the prospect of liquidation when cash levels approach to zero.

[30]Recall that we attribute this value loss to costs of collective action, a severance package or a loss of human capital; none of which are expected to be directly affected by the firm's capital structure.

[31]For simplicity, we assume that bankruptcy costs are high enough so that default taking place prior to the refinancing threshold being hit is never optimal, since any amount of cash in corporate reserves will have to be paid out to debtholders as part of the recovery value.

[Please insert Figure 10 about here]

Yet, as long as the coupon rate is below the default-triggering threshold of the optimally managed firm, there is room for the manager to salvage her tenure by altering the firm's payout policy. To secure shareholders' refinancing though, she has to commit to pay out at a lower threshold in the future when cash balances are higher. The only way that our model allows her to credibly do so is through a voluntary relinquishing of her entrenchment, be it through a renegotiation of a severance package or the transfer of valuable private know-how and/or trade secrets. In this case, shareholders' expectations of a lower payout threshold (blue dotted line of Figure 10) leads to a higher firm value, which secures refinancing and the manager's employment.[32] This voluntary waiving of future bargaining power is our model's version of Zwiebel's (1996) result where the threat of bankruptcy restricts managerial entrenchment.[33]

6.2.2. Debt issuance

Having discussed inherited capital structure, we advance our analysis further by examining the implications of our model on the debt issuance decision. We do so by examining the preferences of the two parties involved with respect to the amount of debt to be issued at a given point in time. To focus the discussion that follows on the degree of convergence of the two parties' disposition to borrow and the amount to be issued, we treat borrowing as a now-or-never decision and assume that there are no issuance costs. Based on these, we determine the optimal amount of debt to be issued for each of the two parties, $B^{*(s)}(C)$ and $B^{*(m)}(C)$ for shareholders and the manager respectively, conditional on cash levels at the time of the decision (C) by solving for

$$B^{*(s)}(C) = \arg\max_{B} \left[V^{B}\left(C+B\right) - V\left(C\right)\right] \tag{58}$$

$$B^{*(m)}(C) = \arg\max_{B} \left[M^{B}\left(C+B\right) - M\left(C\right)\right] \tag{59}$$

where V^B and M^B represent the values to shareholders and managers respectively with debt of face value B outstanding, and V and M represent the corresponding base case values, i.e., when the firm is all-equity financed.

Albeit parsimonious, the design yields some intuitive results, which are summarized in Figure 11. Starting from shareholders' optimization, due to the absence of debt issuance costs, raising money through this

[32] If controlled by the manager, the risk management policy too depends on her ability to give up part of her entrenchment. For instance, if the cost of managerial replacement cannot be credibly reduced, the manager's value function is concave throughout the support $(0, \overline{C})$ and she would be better off with hedging positions at any level of cash. However, if the cost of her replacement can be negotiated down, then her hedging incentives would be similar, ex-post, with the riskless debt case, i.e. as analyzed in Section 5.

[33] We are grateful to an anonymous referee for pointing us to this direction.

alternative source of financing can reduce the probability of the refinancing threshold being hit and hence prevent the incurrence of equity issuance costs. On the other hand, the presence of a coupon rate may reduce value through slower cash accumulation and delayed payouts. Combining these two effects results in an objective function (expression in brackets in (58)) which is hump-shaped for low values of C and monotonically decreasing for moderate and high levels of C. Hence, shareholders gain value by issuing debt only when cash reserves are low and the optimal amount of debt to be issued ($B^{*(s)}$, represented by the blue solid line in Figure 11) decreases in the level of cash at the time of issuance.

Turning to the manager, replenishing the firm's cash reserves with newly issued funds instantaneously increases not only the amount of perks she can extract at the expense of shareholders at the time of issuance, but also future tunneling flows (through the ensuing extension of the payout threshold). On the other hand, a slower cash accumulation speed implies a lower probability of cash balances reaching and remaining close to the payout threshold, which is where fund tunneling is maximized. The resulting objective function (expression in brackets in (59)) is hump-shaped in C and the optimal amount of debt to be issued from the point of view of the manager ($B^{*(m)}$, red solid line) is the one that brings just enough cash to fill corporate reserves up to the corresponding payout threshold ($\overline{C}(B)$, dotdashed line).

Lastly, we plot the roots of the two objective functions to reflect the range of values for which each party would consent to a debt issuance that requires the approval of both sides. The dashed lines represent the break-even initial cash/debt combination, above which value for the respective party ($C^{\overline{B}(s)}$, in blue, for shareholders; $C^{\overline{B}(m)}$, in red, for managers) is destroyed. The red dotted line represents the minimum break-even combination for managers, below which they would not agree to a debt issuance.[34] As such, the shaded area closer to the axes origin represents the region in which issuance will be mutually beneficial, while the shaded area that is located the furthest from the axes origin the one in which a issuing debt is mutually detrimental.[35] The white regions represent areas of disagreement between the two parties on whether debt is to be issued at all.

[Please insert Figure 11 about here]

[34]Recall that the managerial value function is U-shaped, which implies that close to the axes origin, managers are better off forgoing a debt issuance in expectation for a – larger – refinancing using new equity funds.

[35]A further extension of the model incorporating explicit decision rights is needed to formulate predictions about the exact amount of debt to be issued.

6.3. Shareholder activism

The final extension of our main framework involves the possibility of an external intervention, by either activist shareholders or corporate raiders, triggering a shift in the balance of power between shareholders and the manager. Increases in payout is one of the principal objectives of activist investors or funds in firms with high cash holdings and below average returns (Brav, Jiang, Partnoy, and Thomas; 2008). For instance, in a case that was widely reported in 1994 and replicated by other large investors or groups of smaller active investors subsequently, Kirk Kerkorian used his 9% stake in Chrysler as a takeover threat to pressure top management to increase dividends by 60% and announce $1bn in stock buybacks. More recent examples of activists' pressure for higher payouts include Fanuc (in 2015) and Aviva (in 2022), triggering positive daily returns of 6% and 3.3%, respectively, on the day the recommendation to the respective firms' management became public.

6.3.1. Activist investors and raiders

Our model can be modified to allow for the possibility of activist investors launching a campaign demanding an earlier payout. Typically, activists would not (at least not immediately) resort to the replacement of a manager holding higher cash balances than what could be negotiated. We assume instead that activist investors have more negotiating power against managers compared to existing shareholders, that is, a lower cost of managerial replacement ($\gamma' = \gamma - \alpha$), which they are expected to use to drive the payout threshold down.[36] As such, the potential of an activist investor campaign being launched increases the value to shareholders in expectation, but does not affect the value of their current outside option. In other words, the future possibility of a manager complying with investor activist demands adds to the marginal value she brings to the firm today, in comparison with the manager-led firm of the base case model, and works (temporarily) in her favor. Hence, the expectation of an *ex-post* lower payout threshold, $\overline{C}^P$ upon the activists' arrival, leads to an *ex-ante* higher one, $\overline{C}^A$, and $\overline{C}^A > \overline{C} > \overline{C}^P$. From this point on, we use superscript A to denote a pre-activist arrival quantity and P for post-arrival ones.

We also consider an alternative assumption of a more aggressive form of external threat to the manager, such as that of a corporate raider launching a bid to take over the firm. While in this variant too we assume that raiders face a reduced cost of managerial replacement, the replacement of a financially inefficient manager is way more likely to take place in this scenario. Specifically, we distinguish the two cases by eliminating the possibility of a managerial reaction once a raider has arrived. Similar to our baseline model, managerial replacement will take place only if the value of the manager-led firm is less than the value of the raider's

[36] The lower cost of replacement may be attributed, for instance, to a reduced cost of collective action.

outside option of firing the manager (at a reduced cost γ') and running the firm by themselves at the time of takeover (at time τ^R). If the manager is not fired at this instance, implementing thereafter a cash policy where payout occurs as soon as $\overline{C}^P$ is reached (and $\widetilde{C}^P$ is issued as soon as cash reserves are depleted) guarantees a lifelong tenure.

6.3.2. Solution and results

Assuming that an activist investor intervention is arriving at a Poisson rate ξ, the *ex-ante* value of a firm subject to it, $V^A\left(C_t;\widetilde{C}^A,\overline{C}^A\right)$, solves the system

$$\frac{1}{2}\sigma^2 V^{A,j}_{CC}(C) + [\mu + (r-\lambda)C]V^{A,j}_C(C) - (r+\xi)V^{A,j}(c) + \xi V^P(C) = 0 \tag{60}$$

$$\frac{1}{2}\sigma^2 V^{A,jj}_{CC}(C) + [\mu + (r-\lambda)C]V^{A,jj}_C(C) - (r+\xi)V^{A,jj}(c) + +\xi\left[V^P\left(\overline{C}^P\right) + \left(C - \overline{C}^P\right)\right] = 0 \tag{61}$$

where $V^P\left(C_t;\widetilde{C}^P,\overline{C}^P\right)$ represents the value of our base case firm with a cost of managerial replacement of γ'. The solution is completed by the following set of conditions:

$$V^{A,j}(\overline{C}^P) = V^{A,jj}(\overline{C}^P) \tag{62}$$

$$V^{A,j}_C(\overline{C}^P) = V^{A,jj}_C(\overline{C}^P) \tag{63}$$

$$V^{A,j}(0) = V^A(\widetilde{C}^A) - p\,\widetilde{C}^A - \phi \tag{64}$$

$$V^A_C(\widetilde{C}^A) = p \tag{65}$$

$$V^{A,jj}_C(\overline{C}^A) = 1 \tag{66}$$

$$V^{A,jj}(\overline{C}^A) = L(\overline{C}^A) \tag{67}$$

In the case of the external threat being a corporate raider, the manager of a potential takeover target firm may choose to implement of two strategies: i) a payout policy where the *ex-ante* threshold equals the *ex-post* one ($\overline{C}^R = \overline{C}^P$) even before the raider launches a bid, guaranteeing her position in the firm (equivalent to deterring takeover attempts); or ii) a policy where $\overline{C}^R > \overline{C}^P$, taking thus the risk of being replaced if $C_{\tau^R} > \overline{C}^P$. Determining the optimal strategy entails comparing managerial rents from strategy i) to those stemming from the supremum policy of strategy ii), i.e. the payout threshold that maximizes managerial rents from strategy ii). To this end, we split the cash inactivity region into two:

1) For $C_t < \overline{C}^P$ (region j), the manager has the ability to adjust the cash policy of the firm in accordance to the raider's outside option in case the arrival occurs in the next instance and, thus, avoids being replaced

2) For $C_t > \overline{C}^P$ (region jj), the manager is risking to be replaced in the next instance and lose a part of their future rents.

Considering the same arrival rate as with the activist case, ξ, ex-ante shareholder value, $V^R\left(C_t;\widetilde{C}^R,\overline{C}^R\right)$, solves the following system (superscript R to denotes a pre-raider arrival quantity)

$$\frac{1}{2}\sigma^2 V_{CC}^{R,j}(C) + [\mu + (r-\lambda)C]V_C^{R,j}(C) - (r+\xi)V^{R,j}(c) + \xi V^P(C) = 0 \tag{68}$$

$$\frac{1}{2}\sigma^2 V_{CC}^{R,jj}(C) + [\mu + (r-\lambda)C]V_C^{R,jj}(C) - (r+\xi)V^{R,jj}(c) + \xi L^P(C) = 0 \tag{69}$$

subject to the same value-matching, smooth-pasting, and equity issuance conditions (62)–(65) as the activism equivalent, V^A, but the payout policy is determined by the maximization of the present value of managerial rents. The latter satisfies the following system of equations

$$\frac{1}{2}\sigma^2 M_{CC}^{R,j}(C) + [\mu + (r-\lambda)C]M_C^{R,j}(C) - (r+\xi)M^{R,j}(C) + \lambda C + \xi M^P(C) = 0 \tag{70}$$

$$\frac{1}{2}\sigma^2 M_{CC}^{R,jj}(C) + [\mu + (r-\lambda)C]M_C^{R,jj}(C) - (r+\xi)M^{R,jj}(C) + \lambda C + \psi\xi M^P(C) = 0 \tag{71}$$

where ψ is the managerial recovery rate after replacement.[37] The solution is completed with the following conditions:

$$M(0) = M(\widetilde{C}) \tag{72}$$

$$M_C(\overline{C}^R) = 0 \tag{73}$$

$$M^j(\overline{C}^P) = M^{jj}(\overline{C}^P) \tag{74}$$

$$M_C^j(\overline{C}^P) = M_C^{jj}(\overline{C}^P) \tag{75}$$

$$\overline{C}^R = \underset{\overline{C}\in\left[\overline{C}^P,\overline{C}^{R,max}\right]}{\arg\max}\left[M(\overline{C})\right] \tag{76}$$

Note that the space of the manager's choice is constrained by the post-raider arrival payout threshold, $\overline{C}^P$, a reduction below which does not generate any benefit to the manager; and the maximum payout threshold that shareholders are willing to tolerate given their current outside option in anticipation of a lower future payout threshold ($\overline{C}^{R,max} \approx \overline{C}^A$).[38] In the case cash reserves exceed this maximum threshold, shareholders' best course of action would be to forgo the possibility of a raider reducing the cost of managerial replacement and dismiss the current management at once.

[37] We have set this parameter equal to 0 thus far in the paper as its inclusion does not affect our previous results and conclusions, but allow it to vary for this particular extension as the manager's outside option could affect her risk attitude.

[38] For $\overline{C} = \overline{C}^{R,max}$, the only difference between the solution of ex-ante shareholder values of the two cases pertains to the payout to shareholders if cash reserves exceed the ex-post payout threshold at the time of arrival:

1. In the case of activism, shareholders receive a payout adjusting cash reserves to the ex-post cash management policy:

$$V\left(C_{\tau^R}|C > \overline{C}^P\right) = V\left(\overline{C}^P;\widetilde{C}^P,\overline{C}^P\right) + \left(C - \overline{C}^P\right)$$

We examine the impact of three parameters on the pre- and post-arrival payout thresholds for each type of external threat: the managerial replacement cost discount α, the Poisson rate of arrival ξ, and the managerial recovery rate, ψ. The results of our analysis are summarized in Figure 12. For the case of investor activism, we validate that the ex-ante payout threshold, $\overline{C}^A$, increases in both α and ξ, as these boost ex-ante shareholder value; and remains unaffected by ψ as the manager is never at risk of removal. At the same time, the ex-post payout threshold is only (negatively) affected by the reduction in the managerial replacement cost.

Turning to the case of corporate raiders, our analysis reveals that the managerial rent function is U-shaped in the choice of a payout threshold in the $\left[\overline{C}^P, \overline{C}^{R,max}\right]$ range and, hence, her value is maximized on one of the two bounds. In other words, the manager basically decides between taking no risk at all and taking as much of it as possible. This binary choice drives the relation the ex-ante payout threshold $\overline{C}^R$ and α, which is negative for low values of the latter and positive for higher ones: the gain in the manager's rent value from delaying payout is not worth the risk of losing her employment when the reduction in the cost of managerial replacement (and hence the gap between the two payout thresholds) is small; when the latter and the manager's potential gain becomes substantial, the decision is reversed. Lastly, our results confirm that the manager's propensity to risk her tenure (and hence the payout threshold) decreases in the probability of a raider's arrival and increases in the value of her outside option.

[Please insert Figure 12 about here]

7. Conclusions

We develop a cash management model in which two governance-related imperfections, ineffectiveness of monitoring and managerial entrenchment, distort a firm's payout and refinancing decisions. We demonstrate that sufficient levels of managerial entrenchment generate a wide range of cash ratios and a non-monotonic cash value function with respect to cash levels. We further use the model to show that the expression of the

2. In the case of a raider, shareholders get the value of their outside option net of the reduced cost of managerial replacement:

$$\begin{aligned} V\left(C_\tau | C > \overline{C}^P\right) &= V^L(C) - \gamma' V^L(0) = V^L\left(\overline{C}^P\right) - \gamma' V^L(0) + \left[V^L(C) - V^L\left(\overline{C}^P\right)\right] \\ &= V\left(\overline{C}^P; \widetilde{C}^P, \overline{C}^P\right) + \left[V^L(C) - V^L\left(\overline{C}^P\right)\right] \end{aligned}$$

The difference in the two values $\left[V^L(C) - V^L\left(C^P\right)\right] - \left(C - \overline{C}^P\right)$, and hence the difference between $\overline{C}^{R,max}$ and $\overline{C}^A$, is indistinguishable from zero (within 5 digits of precision) for all parameter values attempted.

shareholder-manager conflict with respect to corporate risk-taking is a function of the levels of liquid assets the firm holds.

In the presented model, both managerial entrenchment and the effectiveness of monitoring managerial actions, conflicting facets of corporate governance, lead to later payouts to shareholders and hence higher corporate cash reserves. In addition, they both reduce the marginal value of cash; indicating that restraining the manager's leeway does not necessarily increase the contribution of a dollar of cash to firm value. Turning to the attitude towards risk, a managerial asset substitution problem may give rise to hubris at low cash levels, while the desire of managers for cash reserves to remain high is in line with the hypothesis of "quiet life". Given the risk preferences of shareholders, the model generates a region at moderate cash levels where both shareholders and managers are better off reducing cash flow risk, which hints to an untested hump-shaped relation between corporate cash levels and hedging. If a hedging instrument is available, managers will hedge for relatively high balances, which will result in shareholders demanding an earlier payout. Finally, the presence of an investment opportunity, debt financing, and the threat of shareholder activism generally allow the manager to delay paying out cash to shareholders.

A. Appendix

A.1. Lemma 1

Lemma 1. *For any smooth function $f(x)$ satisfying the differential equation*

$$\frac{\sigma^2}{2} f_{xx}(x) + \left[\mu + (r - \lambda)\, x\right] f_x(x) - r\, f(x) + \delta x = 0 \tag{A.1}$$

its second derivative $f_{xx}(x)$ has at most one root in $\mathbb{R}$.

Proof: Differentiating (A.1) with respect to x yields

$$\frac{1}{2}\sigma^2 f_{xxx} + \left[\mu + (r - \lambda)\, x\right] f_{xx} - \lambda\, f_x + \delta = 0 \tag{A.2}$$

Assume f_{xx} has at least one root, and let the first one being denoted by x^*. Following (A.2), it holds that

$$\frac{1}{2}\sigma^2 f_{xxx}\left(x^*\right) = \lambda\, f_x\left(x^*\right) - \delta \Longrightarrow \operatorname{sgn}\left[f_{xxx}\left(x^*\right)\right] = \operatorname{sgn}\left[f_x\left(x^*\right) - \frac{\delta}{\lambda}\right] \tag{A.3}$$

Hence,

- If $f_x\left(x^*\right) > \frac{\delta}{\lambda}$, then f_x has a minimum at x^*, and
- If $f_x\left(x^*\right) < \frac{\delta}{\lambda}$, then f_x has a maximum at x^*.

Suppose that $f_x\left(x^*\right) > \frac{\delta}{\lambda}$ and thus $f_{xxx}\left(x^*\right) > 0$. Denoting by x_2^* the next root of f_{xx}, it follows that $f_{xx}\left(x\right) > 0$ in $\left(x^*, x_2^*\right)$, and hence $f_x\left(x_2^*\right) > f_x\left(x^*\right) > \frac{\delta}{\lambda}$. For x_2^* to be the next root of f_{xx} though, $f_x\left(x_2^*\right) \leq 0$ has to hold. $f_{xxx}\left(x_2^*\right) \leq 0 < f_x\left(x_2^*\right)$ contradicts (A.3). The proof for $f_x\left(x^*\right) < 0$ is similar and therefore omitted. ■

A.2. Proof of Proposition 1

Applying Lemma 1 to the differential equation (8), for $\delta = 0$, it follows that V_{CC} has at most a single root in $\mathbb{R}$.

Corollary: If V_{CC} has a root in $\mathbb{R}$, denoted by C^*, this would be a global minimum point of V_C.

Proof: If $V_C\left(C^*\right) < 0$, then following Lemma 1, $V_{CCC}\left(C^*\right) < 0$ and C^* would be a maximum point of V_C. Hence $V_C\left(C\right) \leq V_C\left(C^*\right) < 0$ for every $C \neq C^*$, which contradicts conditions (17) and (19).

Corollary: $V(C)$ is an increasing function of C in $\left[0, \overline{C}\right]$.

Proof: Since $V_C(C) \geq V_C(C^*) > 0$, $V(C)$ is an increasing function of C in $\mathbb{R}$.

Next, we show that the change in the concavity in $V(C)$ happens in $\left(0, \overline{C}\right)$, i.e., $C^* \in \left(0, \overline{C}\right)$.

Lemma 2. $V_C(0) > 1$ *and* $V_{CC}(0) < 0$

Proof: Since $V_C(\widetilde{C}) \geq V_C(\overline{C}) > 0$ and because of Lemma 1, V_C is either decreasing throughout $\left[0, \overline{C}\right]$ or is U-shaped in $\left[0, \overline{C}\right]$, depending on whether the root of V_{CC} is located in $\left(0, \overline{C}\right)$. In any case, since $\widetilde{C} > 0$, it follows that $V_C(0) > 1$.

Substituting $C = 0$ in the differential equation (8), obtains

$$V(0) = \frac{\mu}{r} V_C(0) + \frac{\sigma^2}{2\,r} V_{CC}(0) > \frac{\mu}{r} + \frac{\sigma^2}{2\,r} V_{CC}(0) \tag{A.4}$$

where the inequality is due to $V_C(0) > 1$. Given that the value of a firm with zero cash reserves in a frictionless world would be equal to $V^{FB}(0) = \frac{\mu}{r}$ (see Décamps et al., 2011), it follows that $V_{CC}(0) < 0$.

Lemma 3. $V_{CC}(\overline{C}) > 0$

Proof: Given (15), it follows that for a small $\epsilon > 0$

$$V\left(\overline{C} - \epsilon\right) > L\left(\overline{C} - \epsilon\right) \Longleftrightarrow \frac{V\left(\overline{C}\right) - V\left(\overline{C} - \epsilon\right)}{\epsilon} < \frac{L\left(\overline{C}\right) - L\left(\overline{C} - \epsilon\right)}{\epsilon} \tag{A.5}$$

Taking the limit of ϵ on both sides of the inequality obtains $V_C\left(\overline{C} - \epsilon\right) < 1$. Given that $V_C(\overline{C}) = 1$ proves that $V^M_{CC}(\overline{C}) > 0$.

Summarizing Lemmata 2 and 3, we can write $V_{CC}(0) < 0 < V_{CC}(\overline{C})$. Hence $C^* \in \left(0, \overline{C}\right)$, $V_C(C)$ is U-shaped in $\left(0, \overline{C}\right)$. Furthermore, $V(C)$ is concave in $[0, C^*)$ and convex in $\left(C^*, \overline{C}\right]$.

A.3. Proof of Proposition 2

Applying Lemma 1 to the differential equation (24), for $\delta = \lambda$, it follows that M_{CC} has at most a single root in $\mathbb{R}$.

Lemma 4. *The single root of M_{CC} is located in $\left(0, \overline{C}\right)$.*

Proof: From (26) it follows that there is a $\widehat{C} \in \left(0, \widetilde{C}\right)$ where $M_C\left(\widehat{C}\right) = 0$. Given that $M_C\left(\widehat{C}\right) = M_C\left(\overline{C}\right)$, there is a $C^M \in \left(\widetilde{C}, \overline{C}\right)$ where $M_{CC}\left(C^M\right) = 0$.

Lemma 5. $M_{CC}\left(\overline{C}\right) < 0$

Proof: Substituting $C = \overline{C}$ into the differential equation (24) yields

$$M\left(\overline{C}\right) = \frac{\lambda \overline{C}}{r} + \frac{\sigma^2}{2\,r} M_{CC}\left(\overline{C}\right) \tag{A.6}$$

Given that the first term $\left(\frac{\lambda \overline{C}}{r}\right)$ represents the wealth to the manager if cash reserves remained indefinitely at $C = \overline{C}$, it follows that $M_{CC}\left(\overline{C}\right) < 0$.

Combining Lemmata 4 and 5, we deduce that $M_{CC} > 0$ in $\left[0, C^M\right)$ and $M_{CC} < 0$ in $\left(C^M, \overline{C}\right]$. Summarizing, the value to the firm's manager, $M(C)$ is

- decreasing and convex in $\left[0, \widehat{C}\right)$,

- increasing and convex in $\left(\widehat{C}, C^M\right)$, and
- increasing and concave in $\left(C^M, \overline{C}\right)$

A.4. Equity issuance decision

Owners of private companies are likely to have control over the issuance decision but shareholders' control over new equity offerings can vary for firms with more dispersed holding patterns. Differences in requirements across and within countries make it possible for managers to issue equity below a fractional threshold under circumstances without an agreement from shareholders.[39] Furthermore, empirical evidence suggests that managers are able to influence shareholder voting (Bach and Metzger, 2019) and, hence, our assumption of shareholders' exclusive control over the issuance decision may not be universal, even when it is subject to a vote. Therefore, we discuss below a couple of alternative assumptions regarding equity issuance decision rights.

Specifically, we consider two deviations from our assumption in the main text: i) managers decide on the equity issuance timing (and shareholders pick only the amount to be issued, $\widetilde{C}$), and ii) managers decide on the amount to be issued (and shareholders have a say on the timing of the issuance, i.e. they choose the issuance triggering cash level, $\underline{C}$). We illustrate the effect of these alternative assumptions on shareholders' and the manager's value functions in Panels (a) and (b) of Figure A.1 respectively. Similar to the condition prevailing at the payout threshold (the decision on which the manager has full control throughout this paper), if the manager is endowed with control over either quantity of the issuance decision, she will maximize her value extraction when exercising this control. Hence, at the payout trigger too, shareholder value will equate to the value of their outside option:

$$V(\underline{C}) = L(\underline{C}) \tag{A.7}$$

For assumption i) condition (18) is also changed to

$$V(\underline{C}) = V(\widetilde{C}) - p(\widetilde{C} - \underline{C}) - \phi$$

while for assumption ii) condition (A.7) where $\underline{C} = 0$ substitutes condition (19).

As depicted in Panel (a) of Figure A.1, control over the issuance decision both in terms of amount to be issued and its timing is valuable to shareholders. If the manager can proceed with a new issue without the need of (or by manipulating) shareholder approval, she would deviate from the optimal timing and amount issued. Although such as decision would reduce shareholder value and the payout threshold, the manager benefits at the time of issuance from larger amounts and from earlier issuances.[40] In Panel (b) of Figure A.1, the equity issuance proceeds are depicted by the vertical gridlines, while earlier refinancing is reflected by the fact that the support of the value to the manager under assumption i) starts at higher cash levels than the other two functions. The graph reveals that having control over the amount to be issued is more valuable to the manager than control over the timing of the issuance.

Interestingly, the manager value function under either assumption intersects with that of the base case, where both aspects of the issuance decision remain with shareholders. This implies that, although the manager is better off with some control over equity issuance close to refinancing, if given the choice, she would be willing to relinquish it at higher cash balances, as this would allow for a further delay in payouts (via the ensuing increase in shareholder value) and hence a higher tunneling potential. Under the chosen set

[39] Unilateral issuance by the manager (below the fractional threshold triggering a vote) is more often encountered in the case of clustered private placements.

[40] Consistent with this result, Holderness (2018) finds that managerial issuances without shareholder approval lead to a 4% drop in firm value relative to that of approved issuances.

of parameter values,[41] the desire to concede full control of the issuance decision to shareholders happens as soon as refinancing occurs, for both assumptions.

To focus our discussion on the effect of managerial entrenchment on the other consideration made in the paper, we opted for the assumption that minimizes the impact to shareholder value in the main body of text.

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We thank Kristine Hankins (Editor) and an anonymous reviewer for their comments and suggestions. We have also benefited from discussions with Sudipto Dasgupta, Omar El Nayal, Sebastian Gryglewicz, Ufuk Güçbilmez, Fani Kalogirou, Daniel Paravisini, Roberto Steri, David Webb, and participants at the 3rd Cambridge Corporate Finance Theory Symposium, the 4th Annual BELM Corporate Finance Conference (Manchester), the 1st LUMS Corporate Finance Workshop, the ASSET 2019 Conference and the 2021 Annual International Real Options Conference. Panagiotis Couzoff acknowledges the support from FCT Portuguese Foundation of Science and Technology for the project UID/GES/00407/2020. Any remaining errors are ours.

[41] We opted for $\lambda = 2.5\%$ in this Appendix to increase the readability of the graph. Results are qualitatively the same with other values of this parameter.

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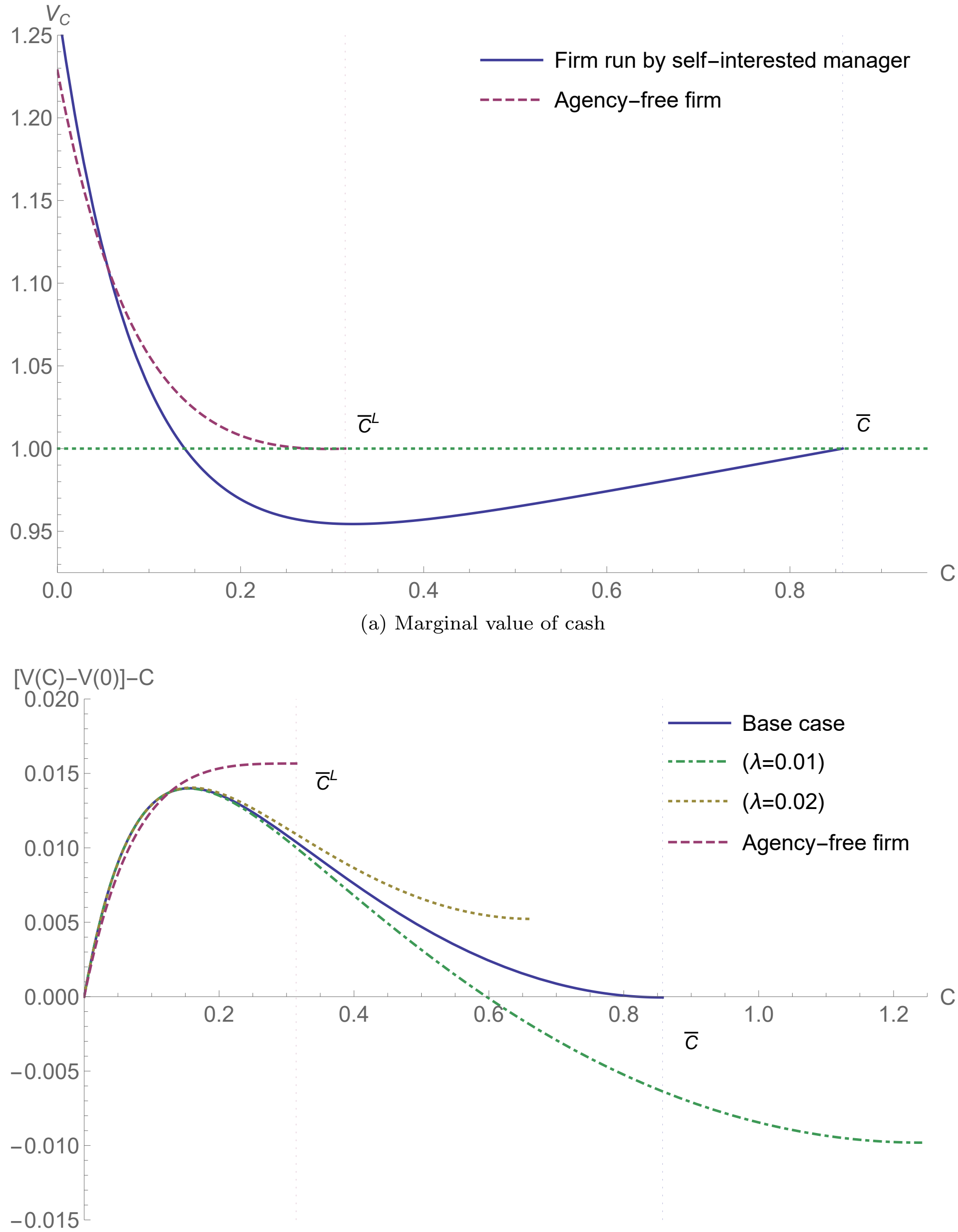
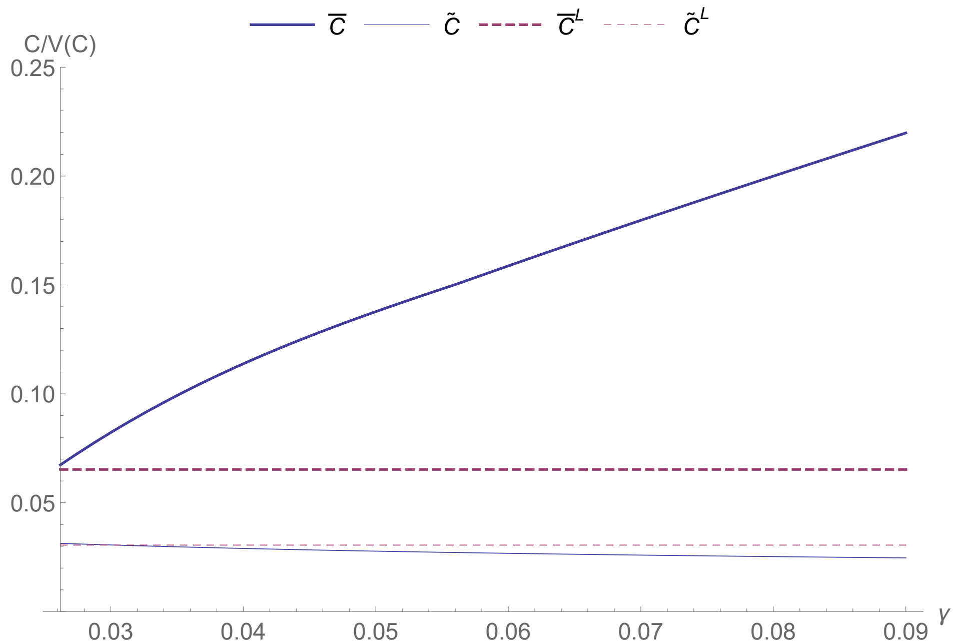


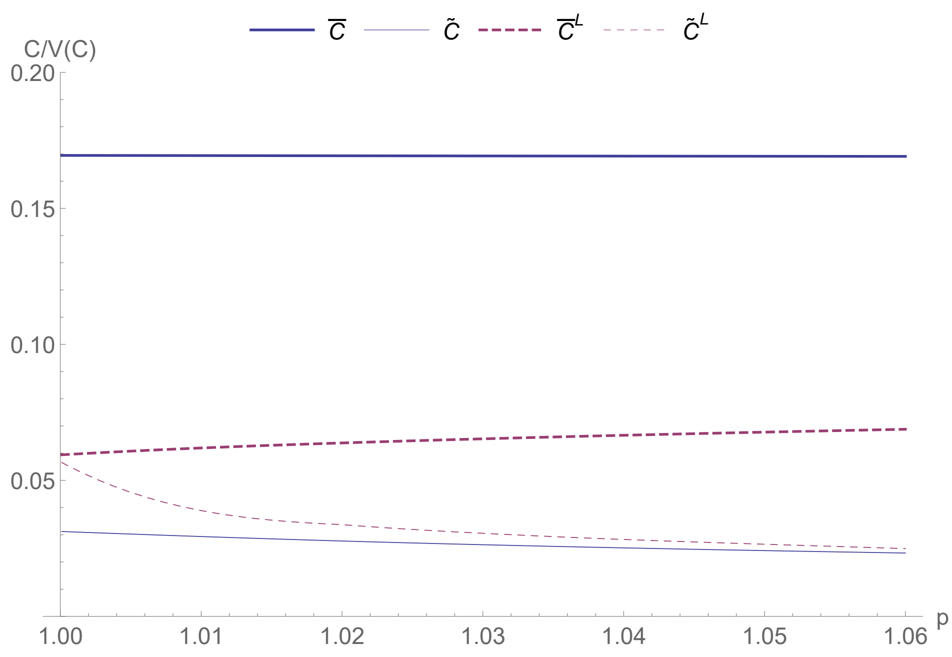
(a) Marginal value of cash

(b) Total value of cash (above face value)

Figure 1: Marginal and total value of cash.
The marginal and total values of cash for the firm run by the self-interested manager (solid line) and the agency-free firm (dashed line), across levels of cash reserves C within the inaction region for each firm. Panel (a) plots the marginal values of cash. The dotted line at $V_C = 1$ represents the marginal value of cash to shareholders in a frictionless setup. Panel (b) plots the difference between the value of cash inside the firm, $V(C) - V(0)$, and its value outside the firm, C for three levels of λ (0.01 for the dotted line, 0.015 for the solid line, and 0.02 for the dot-dashed line). In both panels, the vertical gridlines represent the payout thresholds for the base case firm run by the self-interested manager ($\overline{C}$) and the agency-free firm ($\overline{C}^L$), delineating the respective inaction regions.

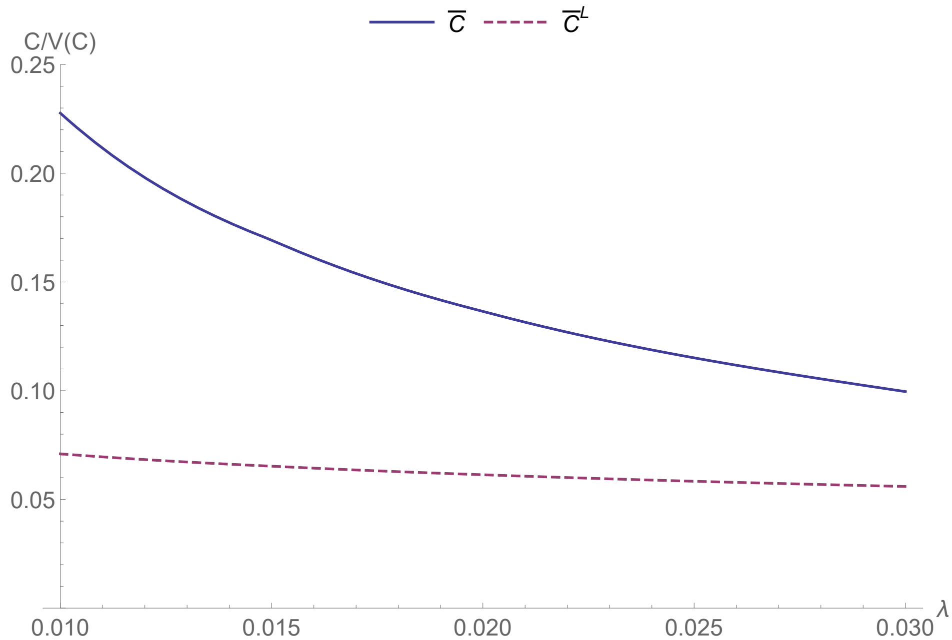


(a) Entrenchment

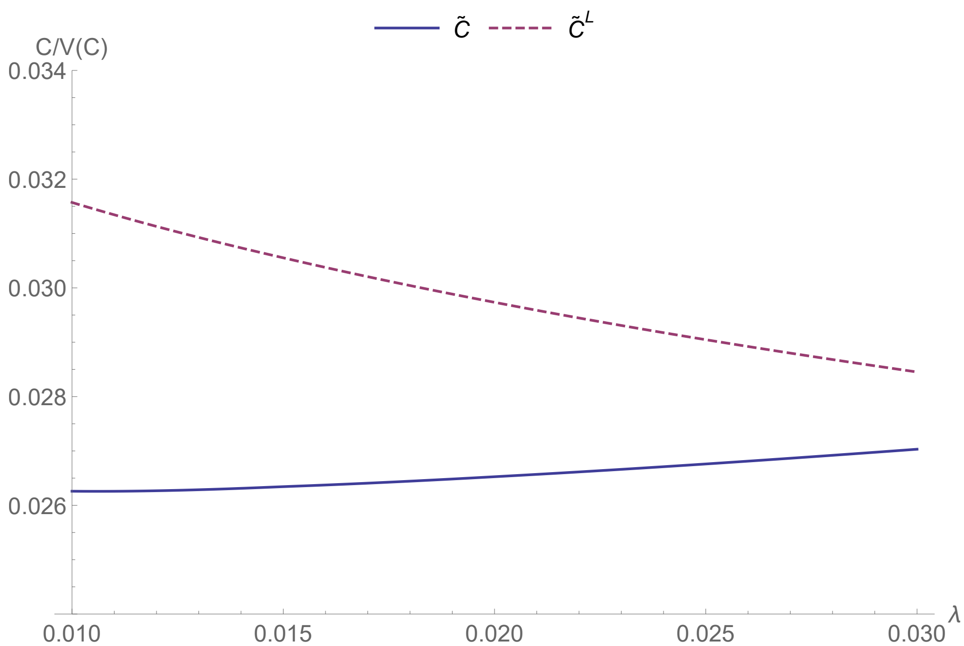


(b) Proportional issuance cost

Figure 2: Effect of entrenchment and proportional issuance costs on cash policies.
The payout threshold (thick lines) and the refinancing target (thin lines) for the firm run by the self-interested manager (solid lines) and the benchmark agency-free firm (dashed lines). In both panels, the payout thresholds ($\overline{C}$, $\overline{C}^L$) and the refinancing targets ($\tilde{C}$, $\tilde{C}^L$) are expressed as ratios of firm value. Panel (a) plots the payout threshold and the refinancing target with respect to values of the entrenchment parameter (γ). Panel (b) plots the payout threshold and the refinancing target with respect to values of the proportional issuance cost parameter (p).



(a) Payout threshold



(b) Refinancing target

Figure 3: Effect of cash return shortfall on cash policies.
The payout threshold and the refinancing target for the firm run by the self-interested manager (solid lines) and the agency-free firm (dotted lines) over values of the cash return shortfall parameter λ. In both panels, the payout thresholds ($\overline{C}$, $\overline{C}^L$) and the refinancing targets ($\tilde{C}$, $\tilde{C}^L$) are expressed as ratios of firm value. Panel (a) plots the payout threshold and Panel (b) the refinancing target with respect to λ.

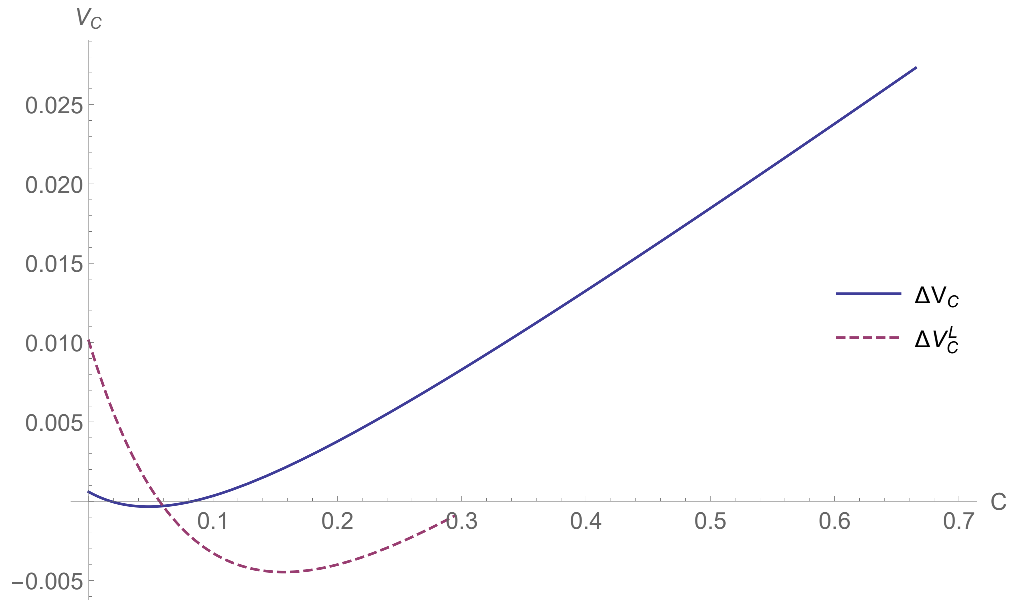


Figure 4: Effect of cash return shortfall on the marginal value of cash.
The change in the marginal value of cash for the firm run by the self-interested manager (solid line) and the agency-free firm (dashed firm) following an increase in λ from 0.01 to 0.02.

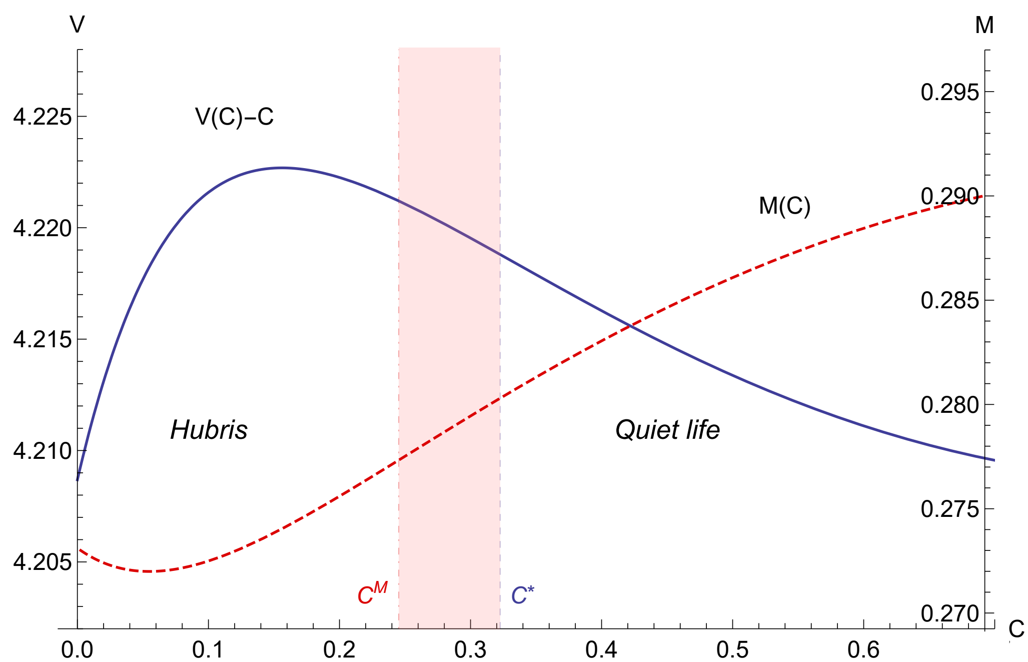
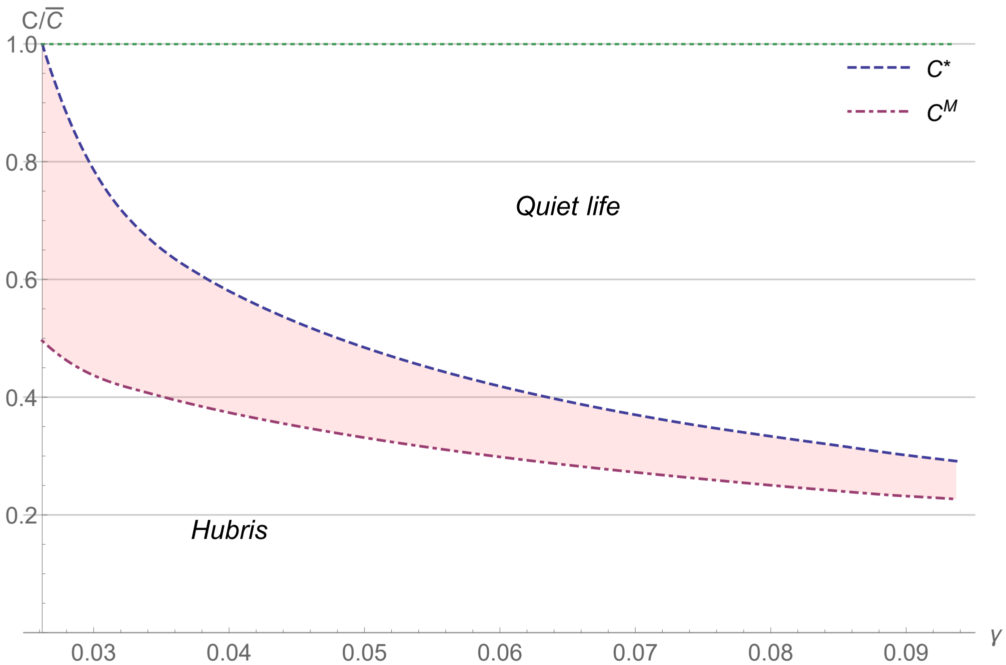


Figure 5: Convexity of shareholders' and manager's value functions.
The value to shareholders net of the face value of cash (solid line) and the value to managers (dashed line) over the level of cash reserves. The plot identifies the levels of cash at which the convexities of shareholder value (C^*) and manager value (C^M) change. The shaded area represents the cash level interval for which both functions are concave.



(a) Entrenchment (γ)

(b) Tunneling (λ)

Figure 6: Effect of entrenchment and tunneling on the collective risk-reducing propensity.
The inflection points of the shareholder value function (C^*, blue line) and the manager value function (C^M, red line) over γ (Panel (a)) and λ (Panel (b)). In both panels, the inflection points are expressed as ratios of the payout threshold ($\overline{C}$). The shaded area represents the cash level interval for which both functions are concave.

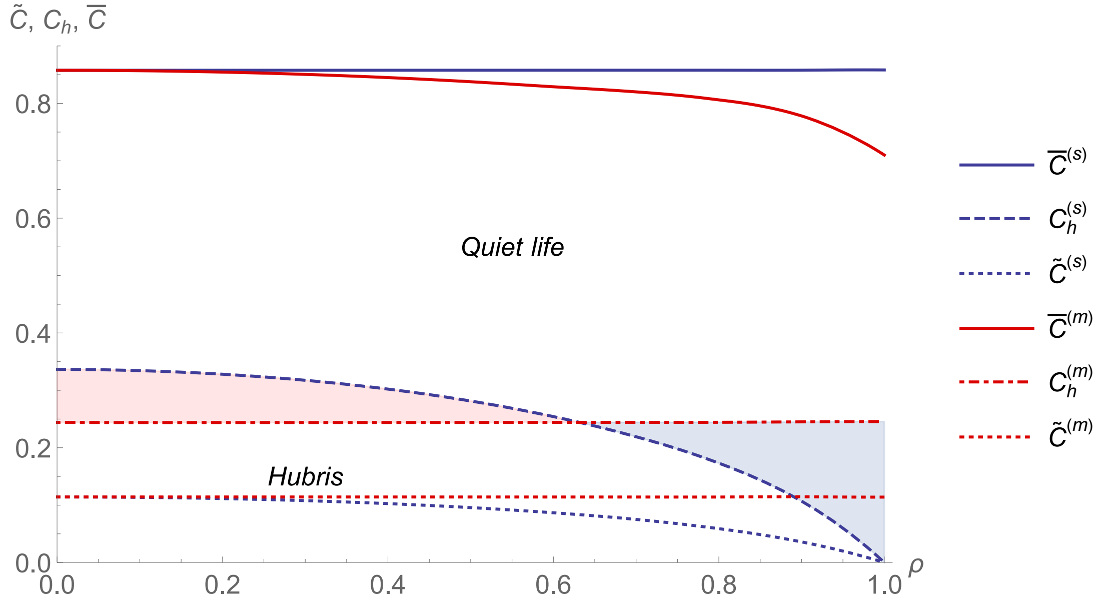


Figure 7: Optimal managerial and shareholder hedging thresholds.
The payout thresholds (solid lines), refinancing targets (dotted lines), and optimal hedging thresholds (dashed and dot-dashed lines) when risk management is controlled by shareholders (blue lines) or the manager (red lines) with respect to the correlation between the returns of the hedging instrument and the firm's cash flows (ρ). The shaded regions indicate the region where shareholders and the manager have consistent risk preferences. The pink (blue) region represents the region where they are in agreement (not) to hedge.

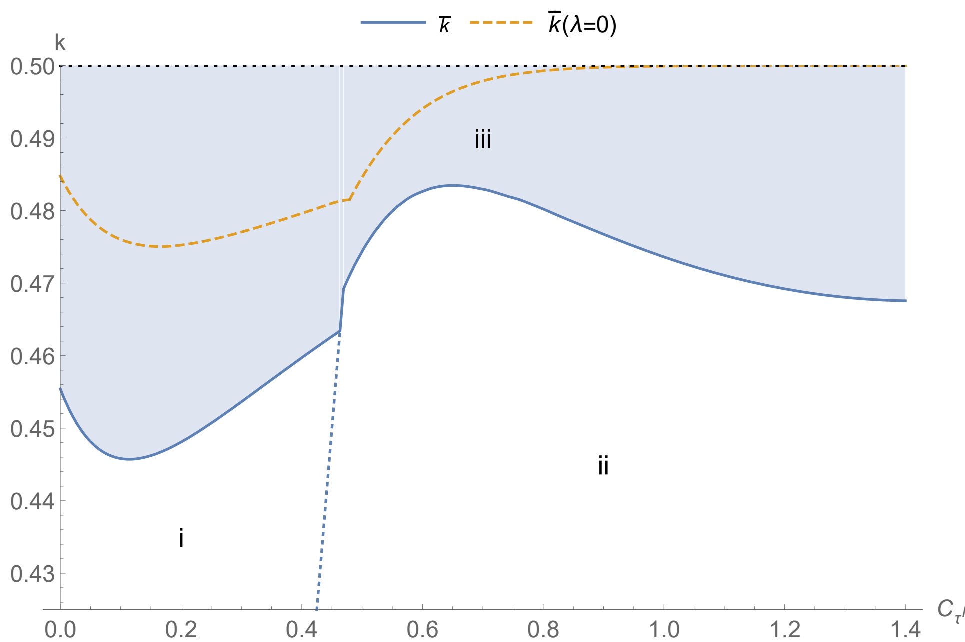


Figure 8: Break-even investment cost.
The break-even investment cost for the manager-led firm (solid line), the shareholder-run firm (dashed line) with respect to the level of cash at the time of arrival of the investment opportunity ($C^A_{\tau^I}$). The frictionless break-even investment cost is $k = 0.5$ (black dotted line). The shaded region (iii) represents the range of cost/cash combinations where no investment takes place. The blue dotted line separates the investment region depending on whether refinancing is needed (region i) or not (region ii).

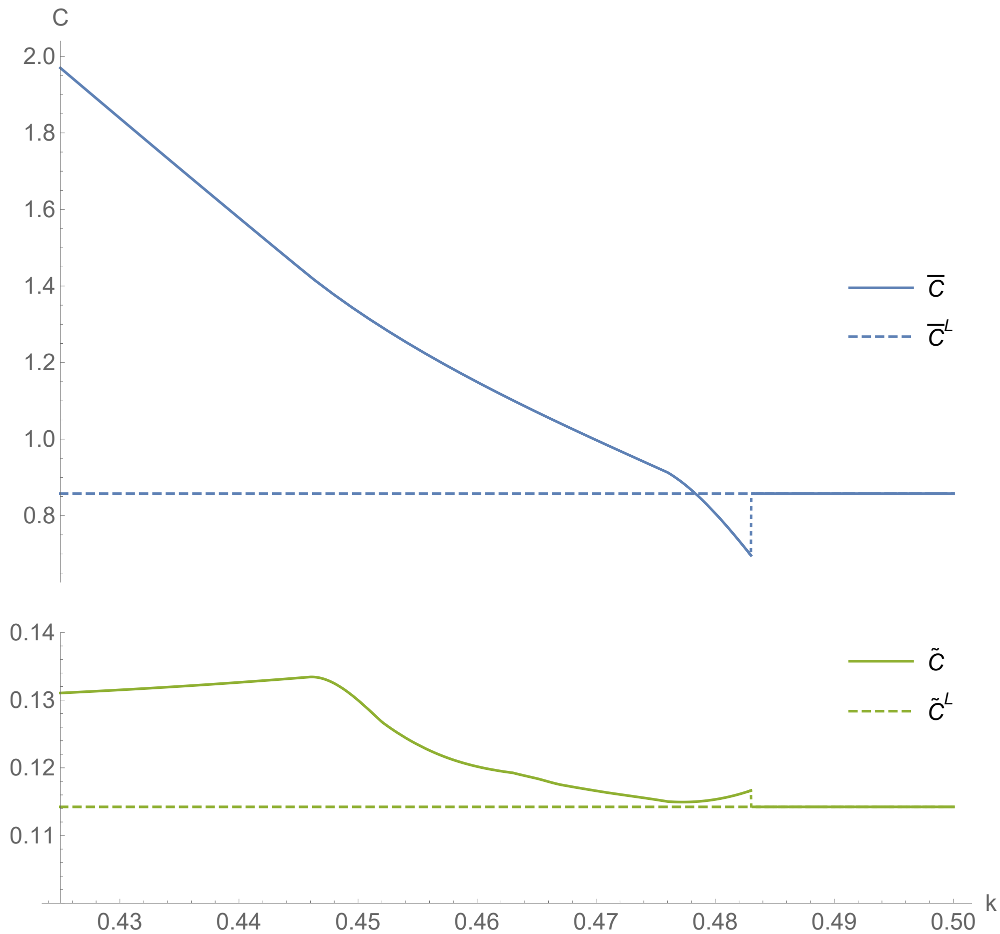


Figure 9: Payout threshold and refinancing barrier at $t = 0$.
The payout thresholds (in blue) and refinancing targets (in green) of the firm run by a self-interested manager (solid lines) and the agency-free firm (dashed lines) prior to the arrival of the investment opportunity (at $t = 0$) with respect to the investment cost (k).

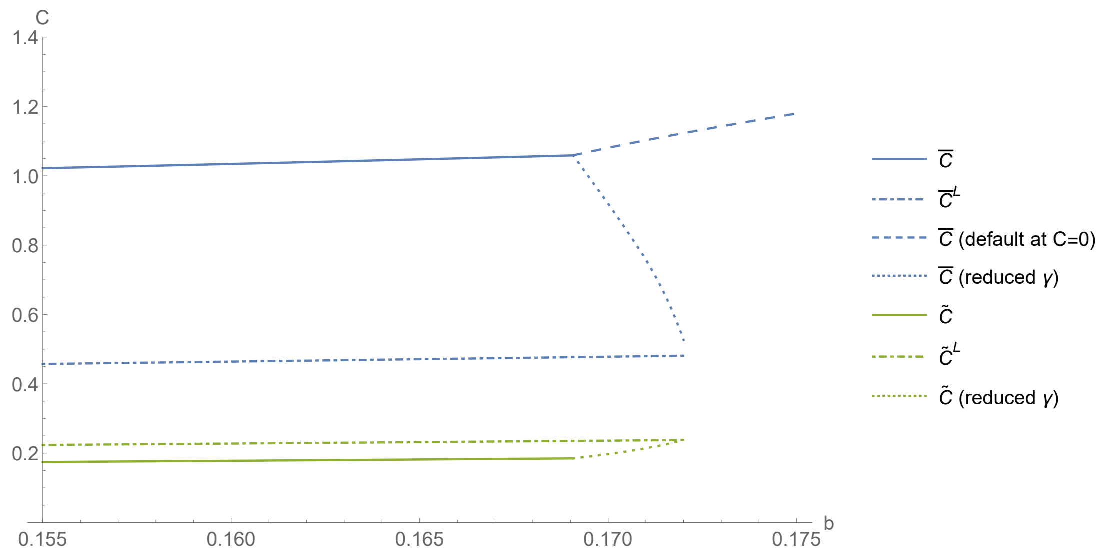


Figure 10: Cash policy of levered firm.
The payout thresholds (in blue) and refinancing targets (in green) of the manager-led and agency-free (dot-dashed) firms with respect to the level of coupon (b). The solid lines represent the cash management policy barriers when debt is risk-free for the base case value of $\gamma = 0.065$ and the dashed line represents the payout threshold when debt is risky. The dotted lines represent the cash management policy barriers for the maximum level of γ for which default on debt is suboptimal for shareholders.

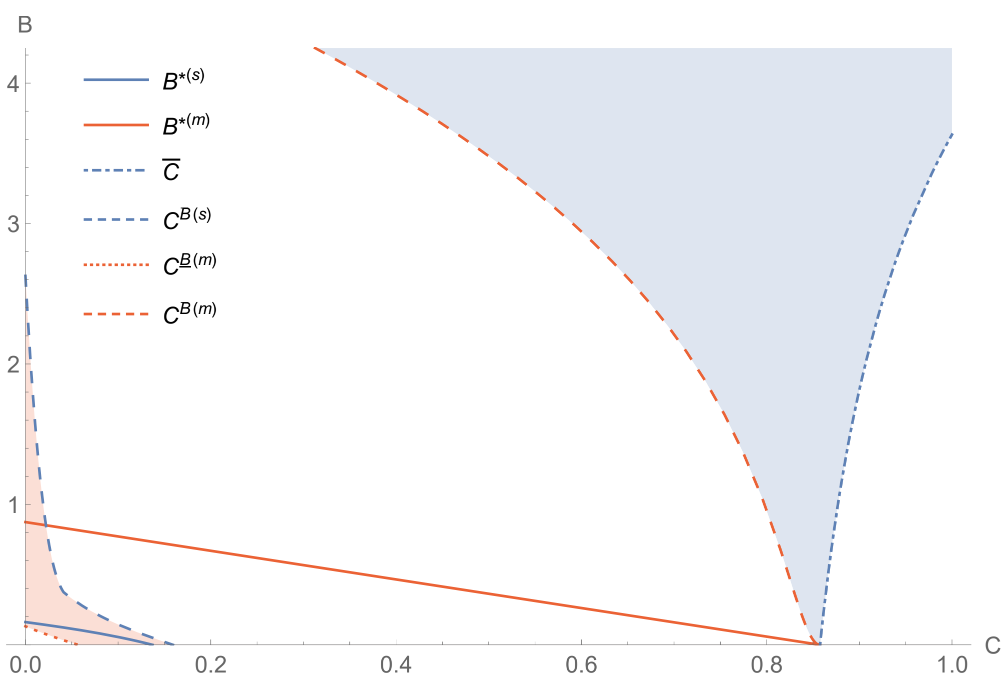
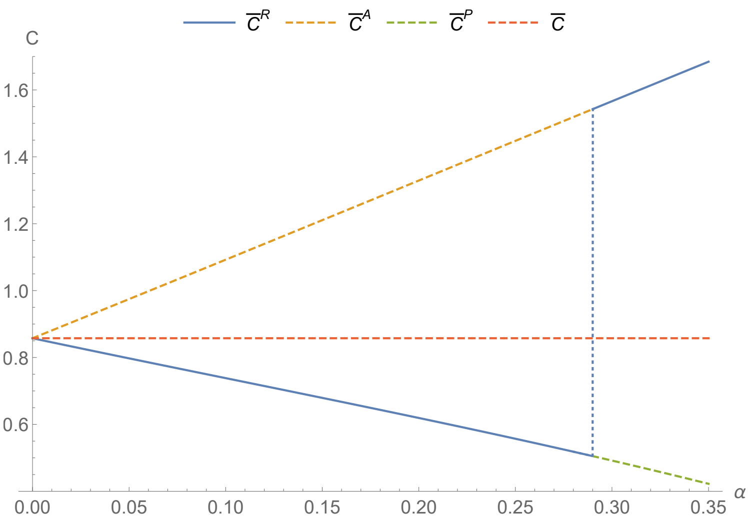
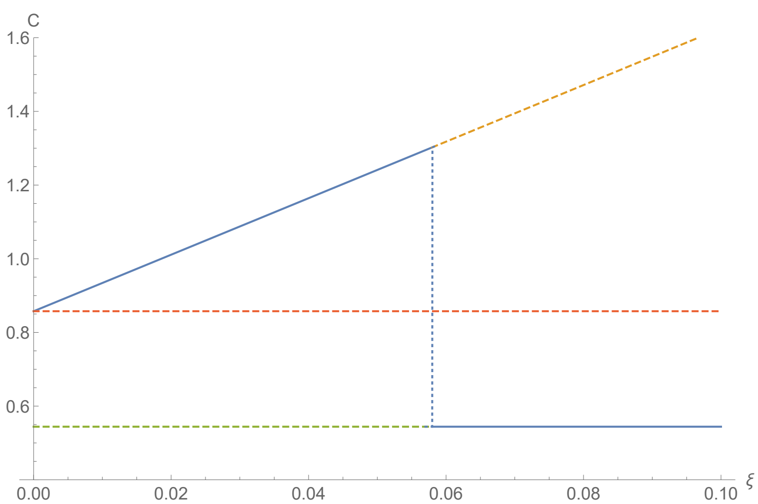


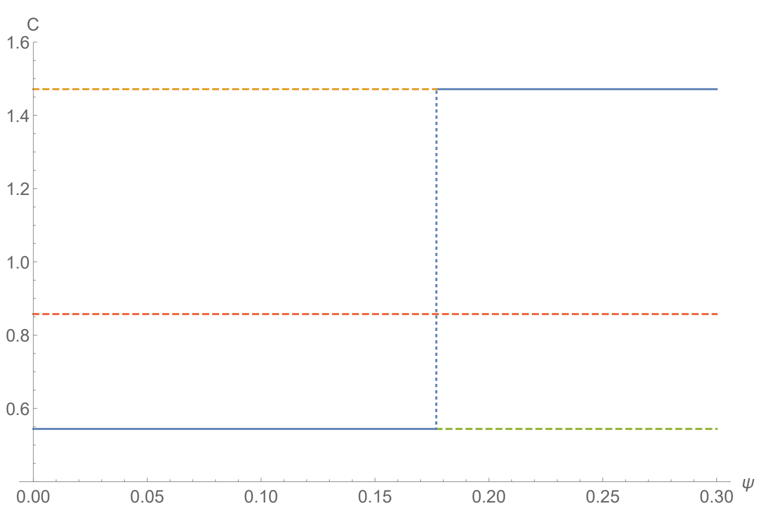
Figure 11: Debt issuance preferences.
The optimal amount of debt issuance for shareholders ($B^{*(s)}$, solid blue line) and for the manager ($B^{*(m)}$, solid red line). The dot-dashed line represents the payout threshold for debt of market value B outstanding. The dashed lines represent the maximum ex-ante cash level for which a debt issuance of B adds value to shareholders ($C^{\overline{B}(s)}$, in blue) and to the manager ($C^{\overline{B}(m)}$, in red). The red dotted line represents the minimum ex-ante cash level for which a debt issuance of B adds value to the manager ($C^{\underline{B}(m)}$). The orange (blue) shaded area represents the range of cash/debt combinations that are mutually beneficial (detrimental) for shareholders and the manager.



(a) Managerial replacement cost discount (α)

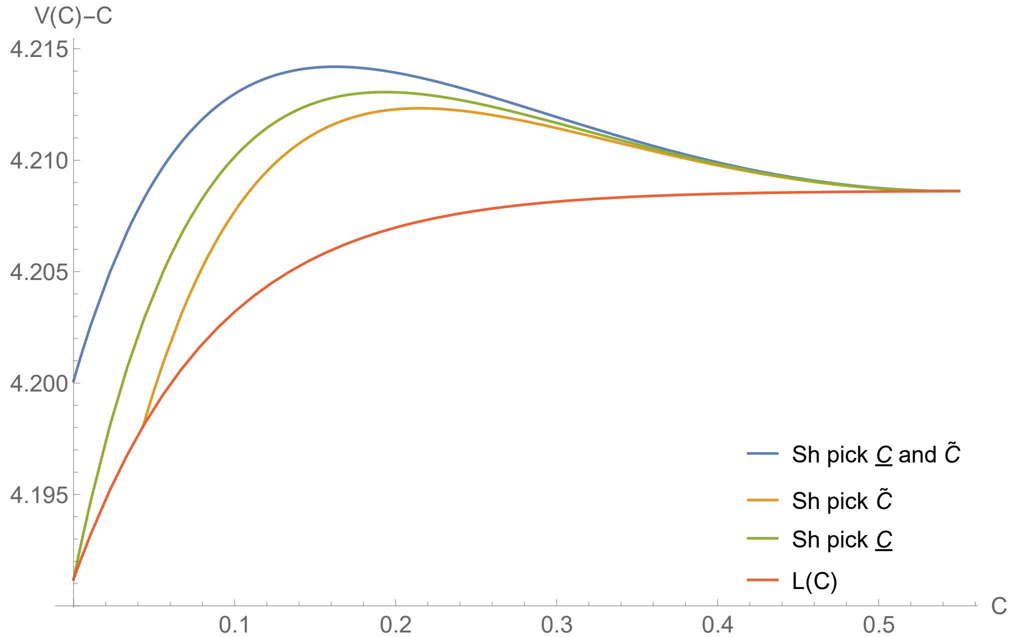


(b) Poisson arrival rate (ξ)

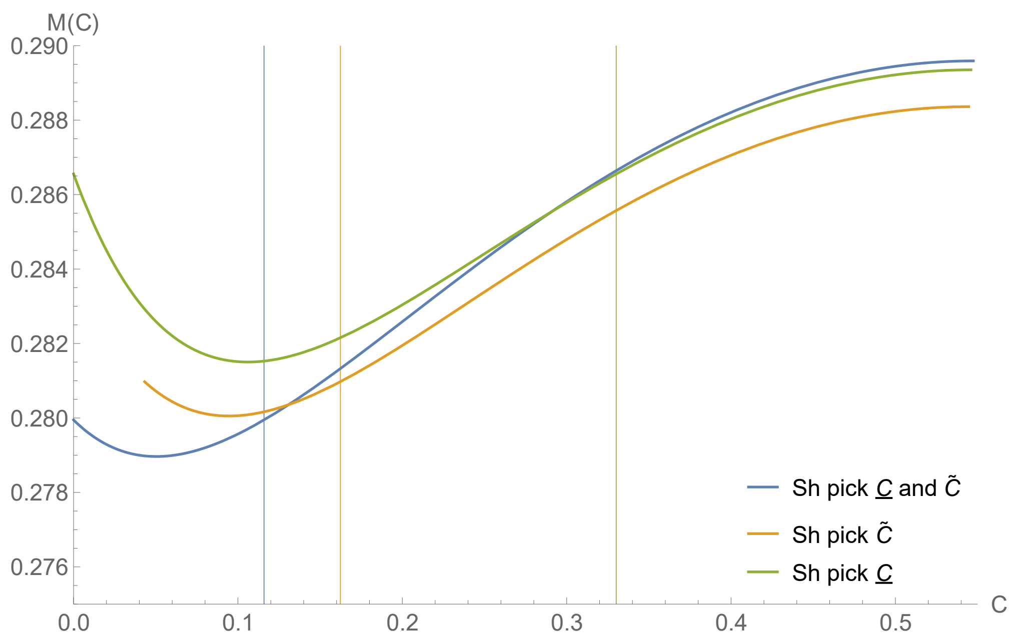


(c) Managerial recovery rate (ψ)

Figure 12: Payout thresholds (external threat).
The payout thresholds of a manager-led firm prior to the arrival of an activist investor ($\overline{C}^A$, orange dashed line) or a corporate raider ($\overline{C}^R$, solid line) with respect to the managerial replacement cost discount α (Panel (a)), the Poisson arrival rate ξ (Panel (b)), and the managerial recovery rate ψ (Panel (c)). The green dashed line, $\overline{C}^P$, represents the payout threshold after the external threat has materialized. The red dashed line represents the payout threshold of the base case, $\overline{C}$.



(a) Shareholder value



(b) Value to the manager

Figure A.1: Impact of equity issuance decision rights.
The shareholder (Panel (a)) and manager (Panel (b)) value functions with respect to cash levels for different allocations of equity issuance decision rights. The blue line represents the value functions of the base case, where both the issuance trigger and the refinancing target are controlled by shareholders. The orange line represents the value functions when shareholders control only the refinancing target, but not the issuance trigger. The green line represents the value functions when shareholders control only the issuance trigger, but not the refinancing target. The gridlines in Panel (b) represent the color-matched refinancing targets for each decision rights allocation. The red line in Panel (a) represents the value of the shareholders' outside option $L(C)$.