Competition for informed trading and corporate short-termism

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Abstract

We provide a rational, information-based theory of corporate short-termism. Our model features a multiperiod speculative market and a corporate sector. Because trading in in long-term assets locks in informed capital for more periods, larger speculative profits are required by informed investors under limited capital. As a result, prices of short term assets become more informative than prices of long term assets. Firms react to this by shortening their project maturities to maximize the benefit of stock-based managerial compensation. As more firms become short-term, this imposes an externality on other firms whose asset prices become even less informative, leading to socially excessive short-termism. Imposing salary caps for corporate managers may exacerbate firms' incentives and lead to more short-termism.

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1 Introduction

Short horizon of managers, regardless of its origins (such as career concerns, impatience), can make pursuing long-term value more costly by worsening managerial moral hazard problem. Using stock-based compensation can help mitigating agency problem because stock prices can be used as a proxy for future performance (e.g., Holmstrom and Tirole (1993)). Therefore, firms that utilize stock-based compensations would want to attract more informed trading to benefit from more informative prices. Because information (thus, informed trading) is scarce resource (e.g., Sims (2003); Hellwig, Kohls, and Veldkamp (2012); Han and Sangiorgi (2015)), however, competition for attracting informed trading can distort firm's decision making, thus, creating undesirable side effects of destroying long-term value.

This paper aims to shed light on understanding the "tragedy of the commons" which creates firms' preference for pursuing welfare-decreasing short-term targets. In particular, we argue that price informativeness of short-term investment opportunities should be higher than that of long-term ones under limited informed capital. Because short-term investment allows informed traders to exploit other investment opportunities more quickly, engaging in long- term investment creates an opportunity cost. In other words, informed traders cannot fully utilize their information production abilities by engaging in long-term investment. Therefore, long-term investment opportunities have to compensate informed traders by offering higher speculative benefits than short-term ones do. Consequently, firms may shorten maturities to enhance own firm value individually by catering to informed traders' short-term preference, but such short-termism in the aggregate level would destroy long-term value by creating negative externality.

We study a multi-period economy in an infinite horizon with a financial market and a corporate sector. There are firms with short-term and long-term technologies in the corporate sector. Firms pay liquidation values to shareholders when their project matures according to their technologies. Short-term technologies tend to mature earlier than long-term ones. Those liquidated firms are replaced by the same mass of new firms. In the financial market, there exists a continuum of risk-neutral investors who are capital constrained. They can acquire private information to trade shares of firms. Investors' expected final wealth becomes greater if they can fully utilize their information production through speculative trading. Because long-term investment tends to mature late, it creates an opportunity cost of not utilizing those valuable resource. Therefore, long-term investment requires higher compensations than short-term investment. This implies that price informativeness of short-term investment should be higher than that of long-term investment.

In the corporate sector, firms choose their technologies, then, managers with moral hazard run the projects. We assume that returns of each technology are diminishing in scale in that the cost of running projects increases as more firms choose the same technologies. Each firm offers an optimal contract to its manager that is contingent on actual cash flows or stock prices. Because stock prices are informative about managerial efforts, more informative prices can enhance firm values by lowering agency costs. As a reaction to such agency cost, shareholders can offer a stock-based compensation where managers receive a higher compensation if prices reveal the success of project regardless of the realization of cash flow. The first-best can be achieved when firms make choice of technologies by equalizing the marginal benefits of short-term and long-term technologies. However, in a competitive equilibrium, firms equalize the average benefits of short-term and long-term technologies rather than the marginal benefits because they should be indifferent between the two technologies in equilibrium. Consequently, the competitive equilibrium is suboptimal relative to the first-best in that shareholder values are not maximized.

The negative spillover effects arise because firms do not internalize adverse effects to other firms when they switch to short-term projects. They shorten their project maturities at the cost of sacrificing the project value to maximize the benefit of stock-based managerial compensation. The firms choose project durations considering the trade-off between attracting investor attention and sacrificing long-term value. When the benefit of informed trading is more pronounced than pursuing long-term value, stock-based compensation can lead to managerial short-termism. In an individual firm perspective, this short-termism per se is not a bad thing because it just reflect the firm's optimal reaction to managerial contracting frictions. However, collective short-termism can be socially undesirable because the total amount of investor attention is fixed regardless of project durations. Reducing project durations would merely change the allocation of investor attention. In doing so, a firm can enhance its own value by reducing the duration (thus, reducing agency cost), but it also destroys the other firm's value. In a symmetric equilibrium where both firms react in the same way, firms would end up reducing durations without any increase in the benefit of informed trading. This race to the bottom leads to the "tragedy of the commons" which creates socially-undesirable spill over effects. Consequently, corporate short-termism creates a deadweight loss in the economy.

Our results have several interesting implications on policies and regulations. our model sheds light on understanding the problem in a different perspective by focusing on financial markets. Because firms with long-term technologies would have to have higher compensation for high stock prices, putting a salary cap would only harm long-term firms rather than short-term firms. This means that such policy would only adversely affect long-term firms, thereby promoting short-termism even further.

The paper is organized as follows: In Section 2, we connect our paper to the existing literature. In Section 3, we describe the basic model. In Section 4.2, we study the financial market equilibrium. In Section 4.3, we solve the optimal contracting problems of each sector. In Section 4.4, we solve for the overall equilibrium where excessive short-termism arises in the corporate sector. In Section 6, we conclude.

2 Literature

There is a long line of literature on both empirical (e.g., Porter (1992); Bushee (1998); Gaspar, Massa, and Matos (2005); Cremers, Pareek, and Sautner (2016); Giannetti and Yu (2016)) and theoretical (e.g., Narayanan (1985); Stein (1989); Bolton, Scheinkman, and Xiong (2006); Aghion, Van Reenen, and Zingales (2013); Thakor (2015); Zeng and Strobl (2016)) sides on managerial short-termism in light of investors' investment horizon.

On the empirical side, Bushee (1998) find that high ownership by short-horizoned investors induces firms' myopic investment. Gaspar, Massa, and Matos (2005) find that firms with short-term shareholders tend to get lower premiums in acquisition bids. Cremers, Pareek, and Sautner (2016) also find that increase in ownership by short-horizoned has an incremental effect on corporate short-termism such as reducing R&D expenses. On the other hand, Aghion, Van Reenen, and Zingales (2013) find that institutional ownership induces more innovations by reducing managers' career concerns. Giannetti and Yu (2016) find that short-term investors can increase firm value by forcing managers to adopt more timely changes in their investment.

Theoretical literature is also mixed in their predictions about whether investor short-termism causes managerial short-termism. Stein (1989) show that managers have myopic investment incentives when their investment choices are not observable. This argument is based on a "signal-jamming" mechanism where managers unfruitfully increase short-term earnings by sacrificing long-term value hoping to boost stock prices even when market prices already incorporate such managerial myopia in equilibrium. Bolton, Scheinkman, and Xiong (2006) show that managerial short-termism still does not disappear even when managerial contracts are endogenized (thus, optimal). In their model, shareholders optimally induce managers to chase short-term profits to exploit speculative options that arise from market optimism. On the other hand, some recent theoretical papers argue that investor short-termism may benefit firm value: Thakor (2015) find that short-term investors may benefit firm value by discouraging management from investing in bad projects that delay information revelation; Zeng and Strobl (2016) also find that short-term activist investors can reduce the cost of moral hazard.

Our paper differ from the existing papers in several ways. First, our paper endogenizes contracts between investors and financial intermediaries. Second, we study a model with multiple firms competing to attract investors who are subject to the cost of moral hazard to incentivize their intermediaries. Third, we have our result is based on negative externality of short-termism that is not well-explored in the literature. Therefore, our paper can deliver the following points that are not highlighted by the existing theoretical papers. We argue that managerial short-termism per se is not a bad thing; it is rather a manifestation of individual profit maximization that would result in enhanced firm value through reduced agency cost. However, we argue that agency cost stays the same regardless of overall durations of firm projects because informed trading itself is scarce resource. That is, equilibrium allocation of informed trading resource, in fact, stays the same with or without competition among firms. Therefore, each firm's individual attempts to enhance firm value actually make everyone worse off in an aggregate perspective. This is why our paper can suggest an interesting policy implication in an different angle from the existing theoretical literature.

3 Setup

We consider a discrete time model in an infinite horizon. There is a continuum of firms with productive technologies, and a continuum of long-lived investors who trade shares of those firms in the financial market. The investors are long-lived, and have risk-neutral preference with a discount factor of β. There exists a risk-free asset in the economy, and its gross return is set to be $R_f = \frac{1}{\beta}$ (the rate of return is denoted by $r_f = R_f - 1$) because the investors are risk-neutral.

3.1 Corporate Sector

At each period, a mass b of new firms enter the economy where b is an exogenously-given parameter. The incumbent shareholders of each new firm are also risk-neutral, and long-lived. They can choose one of the two types of technology of the firm's project: a short-term (S) or a long-term (L) technology. We denote τ_h as the portion of new firms choosing type $h \in \{S, L\}$ technology (i.e., $\tau_S + \tau_L = 1$).

Each firm pays its liquidation value to shareholders then exit the economy when its project realizes the payoff. At every period, a type h firm may get liquidated with probability q_h where $q_S > q_L$. One may interpret the realization of payoffs as an actual distribution of cash flows from projects, but may alternatively interpret it as the realization of capital gains upon public announcements (or information leakage) of the success of projects. Firm i with type h pays R^i which is R^h if the project is successful or zero otherwise. We assume that the present value of firms' expected payoffs are equal regardless of their types.[1] This assumption is made to make both long-term and short-term projects equally valuable in the absence of other forces. On the other hand, the cost of operating a firm varies across types due to endogenously-determined costs. The cost of firm i with type h is given by the sum of $\mathcal{W}_h$, which is the wage bill to the manager, and c_h, which is the cost of investing in type h projects incurred at the initial trading date. We assume that the aggregate cost of investing in type h projects is increasing and convex in the size of investment. That is, it satisfies the usual neoclassical assumptions $\mathcal{C}'_h(\tau_h) > 0$ and $\mathcal{C}''_h(\tau_h) > 0$ for all $\tau_h \in (0, 1)$, $\mathcal{C}'_h(0) = 0$ and $\mathcal{C}'_h(1) = \infty$. For the marginal firm investing in technology h, the cost is given by $c_h = \mathcal{C}'_h(\tau_h)$.

We assume that managers are long lived, and risk-averse. They are subject to limited liability, and also have an outside option that gives a reservation utility of $\bar{u} \geq 0$. The managerial effort choice is private information, and is not verifiable. The project of firm i may succeed with probability $\rho^i(e^i)$, and fail with probability $1 - \rho^i(e^i)$ where e^i denotes the level of the manager's effort which takes either one ("high effort") or zero ("low effort"). We assume that the success of a firm is independent of each other. If the manager exerts high effort, the project is more likely to succeed, i.e.,

[1] The equivalence of the present values implies that R^S and R^L should satisfy the following parametric values:

$$\frac{R^L}{R^S} = \frac{q_S(q_L + r_f)}{q_L(q_S + r_f)}.$$

$$\rho^i(e^i) = \begin{cases} \rho_0 & \text{if } e^i = 0 \\ \rho_1 & \text{if } e^i = 1 \end{cases}.$$

where $\rho_0 < \rho_1$. The manager's utility given his wage $\tilde{w}^i = \{w_t^i\}_{t=0}^{\infty}$ and his effort choice e^i is defined as

$$U\left(\tilde{w}^i, e^i\right) = \sum_{t=0}^{\infty} \beta^t Eu\left(w_t^i\right) + \left(1 - e^i\right) K,$$

where K is the private benefit of the manager, and u is a concave function such that

$$u(x) = \begin{cases} x & \text{if } x < \bar{w} \\ \bar{w} + \gamma\left(x - \bar{w}\right) & \text{if } x \geq \bar{w} \end{cases}.$$

for some constants $\gamma \in (0,1)$ and $\bar{w} > 0$. To ensure that the manager is risk averse over the relevant range, we assume $\bar{w} < \frac{B}{\Delta\sigma}$.[2] To simplify exposition we set $\bar{u}$ small enough that managers' participation constraint never binds under the optimal contract. A compensation contract $\tilde{w}$ for the manager is a non-negative process where each random payment w_t can be made contingent on any information available to shareholders up to t.[3]

3.2 Financial Market

Each investor can produce private information about one firm at each period. All the investors who investigate firm i receive an identical signal $s^i \in \{G, B\}$ which is either good (G) or bad (B). High effort of the manager results in a higher probability that informed investors receive a high signal, $\sigma_1 \equiv pr\left(s^i = G \left| e^i = 1\right.\right) > pr\left(s^i = G \left| e^i = 0\right.\right) \equiv \sigma_0$. At each period, investors are either locked in an existing position, or ready to invest in a new position. In case they are available for new investment, they can decide whether to invest in a long-term or short-term firm. Let δ_h to be the portion of investors investing in type h firms (i.e., $\delta_S + \delta_L = 1$).

[2] Of course, $\rho_H, \rho_L, \sigma_1, \sigma_0, \nu_H, \nu_L$ satisfy

$$\rho_1 = \sigma_1 \nu_H + (1 - \sigma_1)\,\nu_L; \qquad \rho_0 = \sigma_0 \nu_H + (1 - \sigma_0)\,\nu_L.$$

[3] That is, the process $\tilde{w}$ is adapted to the filtration induced by the initial period stock price and the history of the project's payoff. (Note that other firms' payoffs and prices are irrelevant because of independence across projects.)

There are competitive risk-neutral market makers who set prices to clear the market. There are also noise traders who trade for exogenous reasons such as liquidity needs. At each period, the investors and noise traders submit market orders to the market makers. The noise traders submit order flow z which follow an i.i.d. uniformed distribution on $[-\bar{z}, \bar{z}]$. The parameter $\bar{z}$ captures the intensity of noise in the financial market. We assume that $\bar{z} > 1/b$ to ensure that prices do not fully reveal all traded assets.

In our model, informed trading is scarce resource in the economy. To this end, we make the following assumptions. First, we assume that the noise intensity $\bar{z}$ is large enough to make sure that the given mass of informed traders cannot fully reveal every traded firm.[4] Second, we assume that each investor can hold at most $\bar{x}$ unit of positions (either a long or short position) at each point in time, i.e., $x^i \in [-\bar{x}, \bar{x}]$ where x^i is the position of investor i. The underlying idea behind this assumption is that the capital of informed investors is limited, thus, their trading capacities are also limited as such.

4 Equilibrium

Because managerial effort choice is not verifiable, shareholders offer compensation contracts designed to address moral hazard of managers by incorporating stock-based compensations. But, the efficiency of such contracting depends on price informativeness of the firm in the financial market. Therefore, firms optimally choose their production technology by considering both fundamental factors and cost of contracting. On the other hand, investors in the financial market trade off between speculative benefits and investment horizons. Because investors are likely to utilize their information production technologies more frequently with short-term firms than with long-term firms, they require more speculative profits for long-term firms. Consequently, prices of short-term firms are more informative than those of long-term firms to ensure that long-term firms offer higher speculative profits per trade. Knowing this, firms react by lowering their horizons but this may create externalities to other firms, which gives us some implications about efficiency in the economy.

4.1 Equilibrium Definition

We define the equilibrium in a standard manner.

[4] If $\bar{z}$ is small relative to the mass of informed traders, the economy trivially degenerates to one with fully-revealing prices for every single firm.

Definition 1 *The equilibrium is given by the triple* $(\tau_S, \delta_S, \tilde{w})$ *and prices* $\{P_t^i\}$ *which satisfies the following: (i) each manager maximizes his expected utility by choosing effort, (ii) each investor maximize his expected wealth by investing in firms, (iii) initial shareholders of each firm maximize their firm value by offering compensation contract to their manager, and (iv) the price of each firm* i *traded at* t *satisfies*

$$P_t^i = E\left[\sum_{s=t}^{\infty} \beta^{s-t} R_s^i \middle| X_t^i\right],$$

where R_s^i *is cash flow from firm* i *at date* s*, and* X_t^i *is the aggregate order flow.*

As we will show, we solve the overall equilibrium of the model in the following way. First, we first solve price informativeness in the financial market by taking the choice of firms as given (i.e., we obtain δ_S by taking τ_S given). Second, we solve the optimal contracting problem of each firm by taking price informativeness in the financial market as given (i.e., we obtain $\tilde{w}$ by taking δ_S and τ_S given). Finally, we solve the choice of firms on production technologies by incorporating price informativeness and contracts as functions of the choice of firms' technologies (i.e., we obtain equilibrium τ_S by taking the endogenous quantities δ_S and $\tilde{w}$ as functions of τ_S from the previous steps).

To this end, we show that price informativeness should be higher for short-term firms than for the long-term firms (Proposition 2). Shareholders offer optimal contract to managers (Lemma 3). The equilibrium always exists, and is interior. (Proposition 4). We further explore by looking at the efficiency of equilbrium with respect to information spillover effect (Proposition 5 and Proposition 6).

4.2 Trading in the financial market

In this subsection, we study financial market equilibrium keeping the portion of short- and long- term firms fixed. Because investors should be indifferent between investing in long-term firms and short-term firms in equilibrium, we can assume that investors always trade the same type of firms for the convenience of notations and expositions. Therefore, equilibrium in the financial market is pinned down by determining the portion of investors trading short-term (or equivalently, long-term) firms, τ_S (or equivalently, τ_L). Then, we can obtain λ_S and λ_L from those quantities. Because type h investors become free to invest with the rate of q_h, we have $\delta_h q_h$ mass of investors ready to invest in new type h firms. Because investors equalize type-wise speculative profits, the mass of informed trading is equally distributed across all type h firms. In other words, the mass of informed trader who acquire information on each firm should be given by the total mass of investors who acquire information on type h firms divided by the total mass of type h firms. Therefore, the probability of information revelation for a type h firm is given by

$$\lambda_h = \frac{\delta_h q_h \bar{x}}{\tau_h b \bar{z}}.$$

Let $V_\xi^h(w)$ be the value function of an investor who is ready to trade type h firms. We can show that the value function is an affine function of the current wealth as follows:

$$V_\xi^h(w) = \alpha^h + w,$$

where α^h measures the continuation value of an informed investor with type h firms:

$$\alpha^h = \frac{(1-\lambda_h)(1-\beta(1-q_h))\Sigma\bar{x}}{1-\beta},$$

where $\Sigma = \sigma_1(P_h - P_0) + (1-\sigma_1)(P_0 - P_l)$. The proof is relegated to the appendix. Notice that the continuation value increases in q_h, and decreases in λ_h. That is, investors trade-off between speculative benefits and durations.

Because investors should be indifferent between a long-term investment and a short-term investment, we have $\alpha^S = \alpha^L$, or equivalently,

$$\left(\frac{1-\lambda_S}{1-\lambda_L}\right)\left(\frac{1-\beta(1-q_S)}{1-\beta(1-q_L)}\right) = 1. \tag{1}$$

Because $q_S > q_L$, (1) implies that we should have $\lambda_S > \lambda_L$ in equilibrium. Consequently, we find that the informativeness of a short-term firm should be higher than that of a long-term firm to compensate long-term investors for having less frequent speculative profits. Finally, we can find a unique solution for the equilibrium value of δ_S by solving (1). We summarize our findings by the following proposition:

Proposition 2 *(Price informativeness) There exists a unique equilibrium where equilibrium prices of short-term firms are more informative than those of long-term firms.*

Proof. See Appendix. ■

4.3 Optimal Managerial Compensation

In this subsection, we derive the optimal managerial compensation contract of each firm keeping the type of the firm and its price informativeness fixed. In case the stock price is fully revealing, managerial compensation only depends on the informed traders' signal (and not on the subsequent realization of the payoff) because it is a sufficient statistic for manager's effort choice[5] (Holmstrom (1979); Shavell (1979)). In case the stock price is non-revealing, only compensation paid at the liquidation date matters for managerial incentives (in other words, those paid in any other dates than the liquidation date is irrelevant).

Hence, there are only four states relevant for the contract are as follows: (i) the price reveals the signal to be good ($\omega = G$), (ii) the price reveals the signal to be bad ($\omega = B$), (iii) the price is non-revealing and the outcome is a success ($\omega = R$), (iv) the price is non-revealing and the outcome is a failure ($\omega = \emptyset$). A contract will therefore specify non-negative payments corresponding to each of those four states $\left\{w_G^i, w_B^i, w_R^i, w_\emptyset^i\right\}$ and a zero payment in all other states.

Consider a firm i with type h offering a contract to its manager that induces high managerial effort[6][7]. Then, prices of the firm has price informativeness of λ_h by the result of the previous subsection. Shareholders' expected wage expense (or the wage bill), $\mathcal{W}_h$, is given by

$$\mathcal{W}_h = \lambda_h \left(\sigma_1 w_G^i + (1-\sigma_1)\, w_B^i\right) + (1-\lambda_h)\, E\left[\beta^\tau \left(\rho_1 w_R^i + (1-\rho_1)\, w_\emptyset^i\right)\right], \tag{2}$$

where τ is the amount of periods until the liquidation date. An optimal contract $\{w_G^{*i}, w_B^{*i}, w_R^{*i}, w_\emptyset^{*i}\}$ solves the following optimization problem that minimizes the shareholders' wage bill:

$$\min_{\{w_G^i, w_B^i, w_R^i, w_\emptyset^i\}} \mathcal{W}_h, \tag{3}$$

subject to (i) the manager's participation constraint (PC):

$$\lambda_h[\sigma_1 u\left(w_G^i\right) + (1-\sigma_1)\, u\left(w_B^i\right)] + (1-\lambda_h)\, E\left[\beta^\tau \left(\rho_1 u\left(w_R^i\right) + (1-\rho_1)\, u\left(w_\emptyset^i\right)\right)\right] \geq \bar{u}; \tag{4}$$

[5] This follows from the fact that $\rho_1/\rho_0 < \sigma_1/\sigma_0$ which is easily seen to be implied by $\rho_1 > \rho_0$ and $\nu_H > \nu_L$.

[6] It is implicit that we restrict parameters such that it is optimal for the shareholders to induce high managerial effort.

[7] Of course, this conjecture will be correct in equilibrium.

and (ii) the manager's incentive compatibility constraint (IC):

$$\lambda_h \Delta\sigma \left(u\left(w_G^i\right) - u\left(w_B^i\right)\right) + (1-\lambda_h)\,\Delta\rho E\left[\beta^\tau \left(u\left(w_R^i\right) - u\left(w_\emptyset^i\right)\right)\right] \geq K. \tag{5}$$

Then, the solution to the optimization problem (3)-(5) is given by the following lemma:

Lemma 3 *(Manager's optimal contract) For $\lambda_h > 0$ the optimal contract satisfies $w_B^{*i} = w_\emptyset^{*i} = 0$ and either (i) $\gamma > \bar{\gamma}$ and*

$$\begin{aligned} w_G^{*i} &= \frac{1}{\lambda_h \gamma \Delta\sigma}\left(K - \bar{w}\lambda_h (1-\gamma)\,\Delta\sigma\right) \\ w_R^{*i} &= 0 \end{aligned} \tag{6}$$

or (ii) $\gamma \leq \bar{\gamma}$ and

$$\begin{aligned} w_G^{*i} &= \frac{1}{\lambda_h \gamma \Delta\sigma}\left(K - \bar{w}\left(\lambda_h (1-\gamma)\,\Delta\sigma + (1-\lambda_h)\,\Delta\rho \frac{q_h}{1-(1-q_h)\,\beta}\right)\right) \\ w_R^{*i} &= \bar{w}. \end{aligned} \tag{7}$$

where $\bar{\gamma}$ is a constant $\bar{\gamma} \equiv \frac{\sigma_1 \Delta\rho}{\Delta\sigma \rho_1}$. For $\lambda_h = 0$, the optimal contract satisfies $w_\emptyset^{*i} = 0$ and

$$w_R^{*i} = \frac{1}{\gamma}\left(\frac{K}{\Delta\rho}\left(\frac{q_h}{1-(1-q_h)\,\beta}\right)^{-1} - \bar{w}\,(1-\gamma)\right). \tag{8}$$

Furthermore, shareholders' wage bill $\mathcal{W}_h$ is strictly decreasing in λ_h.

Proof. See Appendix.

Lemma 3 implies that firms benefit from a more efficient stock price (higher λ_h) because it allows them to write better compensation contracts with managers and reduce the agency cost. By Proposition 1, equilibrium in the financial market demands short term firms to have more informative prices than long term firms. The combination of these two forces is the key effect in our model and implies that short term firms anticipate a lower agency cost.

4.4 Solving Equilibrium

Now, we turn to solving the equilibrium of the model by incorporating informed trading and managerial contracts into the technology choice of firms. In equilibrium (where τ_S^*

fraction of firms choose the short-term technology), firms should be indifferent between long- and short-term projects. That is, the marginal firm choosing short-term project should have the same profit of a long-term project:

$$\rho_1 R - \left(\mathcal{C}_S'\left(\tau_S^*\right) + \mathcal{W}_S\right) = \rho_1 R - \left(\mathcal{C}_L'\left(1-\tau_S^*\right) + \mathcal{W}_L\right),$$

or equivalently, we have

$$\mathcal{C}_S'\left(\tau^*\right) - \mathcal{C}_L'\left(1-\tau^*\right) = \mathcal{W}_L - \mathcal{W}_S. \tag{9}$$

In a competitive equilibrium, the marginal firm trades off lower agency cost in the short-term sector ($\mathcal{W}_L - \mathcal{W}_S > 0$ by Lemma 3) with larger NPV in the long-term sector ($\mathcal{W}_L - \mathcal{W}_S > 0$ and (9) imply $\rho_1 R - \mathcal{C}_S'\left(\tau^*\right) < \rho_1 R - \mathcal{C}_L'\left(1-\tau^*\right)$). We remark that we did not assume short-term firms to be less productive; the lower profitability of short-term firms is an equilibrium outcome and it would obtain even if the short term technology were to be more efficient, such as $\mathcal{C}_S\left(x\right) < \mathcal{C}_L\left(x\right)$ for all x.

Proposition 4 *(Existence of equilibrium) There exists an equilibrium in the economy. In equilibrium, both short- and long- term production technologies are chosen by firms, i.e.,* $\tau_S^* \in (0,1)$.

Proof. See Appendix.

4.5 Spillover effects

Because short-term firms have more informative prices than long-term firms do, they may be able to enjoy the benefit of price informativeness. In the next section, we endogenize firms' choice of technologies by making firm values sensitive to price informativeness. If price informativeness enhances firm value, more firms would want to switch to short-term technologies. However, we find that the increase of short-termism resulting from firm value maximization leads to the decrease in price informativeness of other firms.

Lemma 5 *(Spillover effects) Increasing the mass of firms with shorter maturities decreases the price informativeness of all firm if and only if*

$$\frac{\bar{x}}{b\bar{z}} < \frac{1}{q_S + q_L + r_f}.$$

Proof. See Appendix. ■

There are two forces that shape spillover effects of short-termism. The first effect is a static one: as more firms become short-horizoned, they attract more informed investors to their side, thereby decreasing the mass of informed investors in other firms. Therefore, it creates a negative spillover effect. The second one is a dynamic one: as more firms become short-term, those firms free informed investors at a faster rate than long-term firms do, thereby increasing overall amount of available informed investors in the market. Therefore, it creates a positive spillover effect. Consequently, the overall effect is determined by the relative strength of these two effects.

4.6 Efficiency Analysis

Notice that the mass of informed trading depends on the relative level of durations rather than the absolute level of durations. That is, one firm's gaining investor attention is the other firm's loss in their investor attention. Reducing durations merely change allocations of investor attention without changing the total benefit of informed trading. Because firms do not internalize such negative spill over effect to each other, competition for attracting investor attention can lead to a race to the bottom as we will show in the subsequent section.

Firms' technological choices are individually optimal: for an individual firm the lower productivity is of the short-term technology is exactly compensated by the higher price informativeness relative to the long-term technology. To evaluate the aggregate properties of this competitive outcome, consider a benchmark in which a planner chooses τ to maximize net output (shareholder value) taking financial market equilibrium and firm's optimal contracts as given. Denote τ^{SB} this value maximizing choice:

$$\tau^{SB} \equiv \arg\max_{\tau\in[0,1]} \rho_1 R - \mathcal{C}(\tau) - \mathcal{C}(1-\tau) - (\tau \mathcal{W}_S + (1-\tau)\mathcal{W}_L). \tag{10}$$

The first order derivative for this problem reads

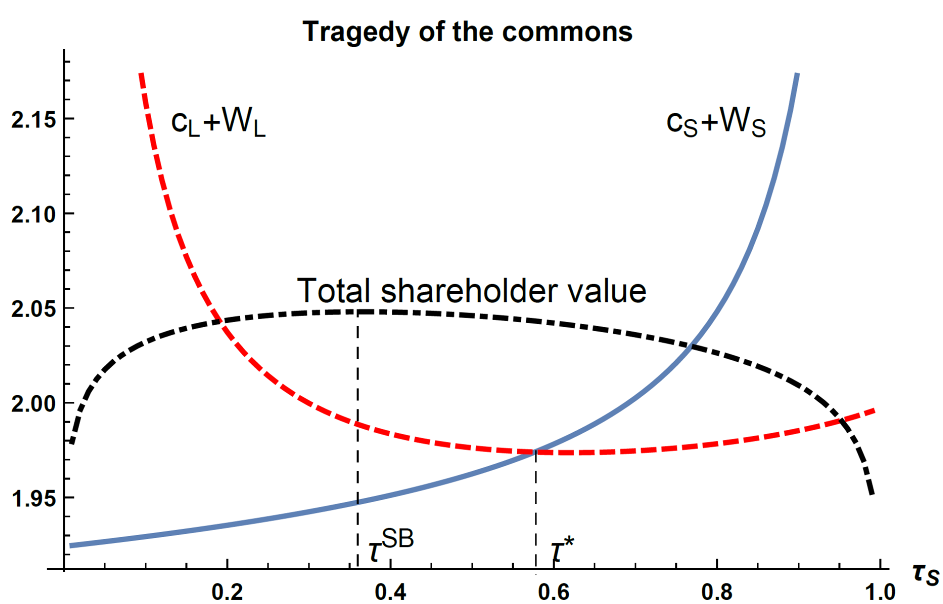
$$\underbrace{\left(-\mathcal{C}'(\tau) + \mathcal{C}'(1-\tau) + \mathcal{W}_L - \mathcal{W}_S\right)}_{=0 \text{ at } \tau^*} \underbrace{- \left(\tau \frac{d\mathcal{W}_S}{d\lambda_S}\frac{d\lambda_S}{d\tau} + (1-\tau)\frac{d\mathcal{W}_L}{d\lambda_L}\frac{d\lambda_L}{d\tau}\right)}_{\mathcal{E}}. \tag{11}$$

The term $\mathcal{E}$ captures the externality that an increase in short-term firms imposes on other firms. This is the average marginal effect that an increase in short-term firms has on firms' agency cost through its effect on price informativeness. Because $\mathcal{W}_h$ is decreasing in λ_h, then $\mathcal{E}$ has the same sign of $\frac{d\lambda_h}{d\tau}$ for $h = L, S$. Hence, $\frac{d\lambda_h}{d\tau} < 0$ implies $\mathcal{E}$ <0 and (11) is negative at a competitive equilibrium τ^*. That is, a marginal reduction in the fraction of short-term firms improves the value of the planner's problem in (10). As a result, we must have $\tau^{SB} < \tau^*$ and therefore the competitive equilibrium features *excessive short-termism.* Of course, the reason for the inefficiency is that firms don't internalize how their choice of project duration affects other firms' price informativeness and agency costs.[8] The next proposition summarizes these findings.

Proposition 6 *(Spillover effect and efficiency) In presence of negative (or positive) spillover effects in price informativeness across firms,* $\frac{d\lambda_h}{d\tau} < 0$, *the competitive equilibrium features excessive short- (or long-) termism,* $\tau^* > \tau^{SB}$.

Proof. See Appendix.

We have already observed that at a competitive equilibrium, short-term firms are less productive than long-term firms. Proposition 6 implies that this lower productivity of short-term firms is excessive and comes at a loss in shareholder value. Figure 5 provides an illustration of these results.



[8]In fact, this is an example of a "tragedy of the commons" whereby individual actors decide among different options based on the average profitability without internalizing the marginal effect of their actions.

FIGURE 5. Parameter values: $\rho_1 = 0.8$, $R = 5$. $\mathcal{C}(\tau) = 0.025(-\tau - \log(1-\tau))$. Other parameter values as in Figure 2.

5 Discussion

There is a debate on whether placing a salary cap on executive compensations can prevent short-termism. The idea is that executives who are motivated by short-term stock market performances would pursue short-term benefits rather than long-term values. Therefore, limiting price-contingent compensations may achieve better outcomes under certain conditions. On other hand, our model sheds light on understanding the problem in a different perspective by focusing on financial markets. Because firms with long-term technologies would have to have higher compensation for high stock prices, putting a salary cap would only harm long-term firms rather than short-term firms. This means that such policy would only adversely affect long-term firms, thereby promoting short-termism even further. The following is a direct consequence of the results in the previous section.

Proposition 7 *(Adverse effect of salary cap) (i) Long-term firms have higher compensations for high prices, (ii) Salary cap first limits the contracting space of long-term firms, thereby lowering firm value of long-term firms, (iii) Salary cap can create more short-termism.*

Our results also imply that encouraging firms to have longer horizon (e.g., tax benefits on R&D expenses) may improve overall welfare. Although stock-based compensation may induce welfare-reducing corporate short-termism, we argue that abolishing stock-based compensation is not a solution at all. It is merely proving that there are contractual frictions that make stock-based compensation optimal for firms, and indeed it is useful in enhancing firm value. The crucial problem is that there is too much competition for too little resource. In case of the tragedy of the commons (e.g., Hardin (1968)), those participants who create negative spill over effects do not internalize them into their utility maximization problems. The standard textbook solution would be penalizing those who create negative externality through tax or regulations so that externality can be internalized: taxing short-term oriented investment can be considered as long as we can identify welfare-reducing short-termism. If identifying negative spill over effects may be difficult, however, our results also suggest that improving market efficiency or reducing contractual frictions in financial intermediation could be equally effective in preventing corporate short-termism. Recently, whether imposing taxes on trading profits would be an effective measure to prevent corporate short-termism. One interesting implication of our results is that taxes on trading may lead to even more serious short-termism because it may reduce stock market price efficiency rather than promote it.

6 Conclusion

We provide a rational, information-based theory of corporate short-termism. Our model features a multiperiod speculative market and a corporate sector. Because trading profits in long-term assets take more time to realize, higher speculative profits are required by informed investors with limited trading capacity. As a result, long-term assets have less informative prices than short-term assets. Firms react to this by shortening their project maturities to maximize the benefit of stock-based managerial compensation. As more firms become short-term, an externality is imposed on long-term firms whose stock prices become even less informative, leading to socially excessive short-termism. Salary caps for corporate managers may exacerbate firms' incentives and lead to more short-termism.

We provide a rational, information-based theory of corporate short-termism. Our model features a multiperiod speculative market and a corporate sector. Because trading profits in long-term assets take more time to realize, higher speculative profits are required by informed investors with limited trading capacity. As a result, long-term assets have less informative prices than short-term assets. Agency costs induce the principals optimally induce agents to focus on short-term performance that would sacrifice long-term value. That is, firms react to this by shortening their project maturities to maximize the benefit of stock-based managerial compensation. As more firms become short-term, an externality is imposed on long-term firms whose stock prices become even less informative, leading to socially excessive short-termism. Salary caps for corporate managers may exacerbate firms' incentives and lead to more short-termism. Our results imply that encouraging firms to have longer horizon (e.g., tax benefits on R&D expenses) may improve overall welfare. However, salary cap may only adversely affect long-term firms, thus, it may actually promote short-termism instead of promoting it.

Appendix

The derivation of the value function. The posterior probability of a high payoff conditioning on a high and low signal is given by ν_1 and ν_0, respectively, where $1 > \nu_1 > \rho > \nu_0 > 0$.

Consider an investor who specialize in trading type h firms. We denote $V^h_\xi(w)$ to be the value function without holding a position given wealth w:

$$V^h_\xi(w) = \beta[(\sigma_1 U^h(w,1) + (1-\sigma_1)U^h(w,0))], \tag{12}$$

where $U^h(w,s)$ is a function of wealth w and signal s:

$$\begin{aligned} U^h(w,s) = \lambda_h\Big[& q_h(\nu_s V^h_\xi(R_f w + (R^h - R_f P_s)x_s) + (1-\nu_s)V^h_\xi(R_f w - R_f P_s x_s)) \\ &+ (1-q_h)V^h_\pi(R_f w - R_f P_s x_s, x_s)\Big] \\ &+ (1-\lambda_h)\Big[q_h(\nu_s V^h_\xi(R_f w + (R^h - R_f P_0)x_s) + (1-\nu_s)V^h_\xi(R_f w - R_f P_0 x_s)) \\ &+ (1-q_h)V^h_\pi(R_f w - R_f P_0 x_s, x_s)\Big], \end{aligned} \tag{13}$$

and $V^h_\pi(w,s)$ is the value function with holding a position given wealth w and signal s:

$$V^h_\pi(w,s) = \beta[q_h(\nu_s V^h_\xi(R_f w + R^h x_s) + (1-\nu_s)V^h_\xi(R_f w)) + (1-q_h)V^h_\pi(R_f w, s)]. \tag{14}$$

We conjecture

$$V^h_\xi(w) = \alpha^h + w, \tag{15}$$

where α^h is a constant. Similarly, we also conjecture that $V^h_\pi(w) = \alpha^h_\pi + w$ where α^h_π is a constant, which in turn implies

$$V^h_\pi(R_f w, s) = V^h_\pi(w,s) + r_f w. \tag{16}$$

Then, substituting (15) and (16) into (14) gives us

$$V^h_\pi(w,s) = \beta[q_h\alpha^h + q_h\nu_s R^h x_s]/\Upsilon^h + w, \tag{17}$$

Therefore, this confirms that the conjecture that $V^h_\pi(w) = \alpha^h_\pi + w$ is indeed true under the conjecture in (15).

Substituting (15) and (17) into (13) yields

$$U^h(w,s) = \left[\frac{q_h}{1-\beta(1-q_h)}\right]\alpha^h + \left[\frac{q_h\nu_s R^h}{1-\beta(1-q_h)} - R_f(\lambda_h P_s + (1-\lambda_h)P_0)\right]x_s + R_f w. \tag{18}$$

Because $q_h\nu_s R^h = R_f(1-\beta(1-q_h))P_s$, (18) implies

$$U^h(w,s) = \left[\frac{q_h}{1-\beta(1-q_h)}\right]\alpha^h + R_f(1-\lambda_h)(P_s-P_0)x_s + R_f w. \tag{19}$$

Because $x_s = \bar{x}$ if $s=1$ and $x_s = -\bar{x}$ if $s=0$, we have

$$V_\xi^h(w) = \beta\left[\frac{q_h}{1-\beta(1-q_h)}\right]\alpha^h + (1-\lambda_h)\Sigma\bar{x} + w, \tag{20}$$

where $\Sigma = \sigma_1(P_H - P_0) + (1-\sigma_1)(P_0 - P_L)$ For the conjecture in (15) to be true, we need

$$\alpha^h = \beta\left[\frac{q_h}{1-\beta(1-q_h)}\right]\alpha^h + (1-\lambda_h)\Sigma\bar{x} \tag{21}$$

Solving (21) for α^h yields the following:

$$\alpha^h = \frac{(1-\lambda_h)(1-\beta(1-q_h))\Sigma\bar{x}}{1-\beta}. \tag{22}$$

This proves that our conjecture in (15) is indeed true.

Proof of Proposition 1.The proof that $\lambda_S > \lambda_L$ is already given in the main text. We now prove existence and uniqueness of the equilibrium. The equilibrium condition implies

$$(1-\lambda_S)(1-\beta(1-q_S)) = (1-\lambda_L)(1-\beta(1-q_L)),$$

or equivalently,

$$\left(b\bar{z} - \frac{\delta_S q_S\bar{x}}{\tau_S}\right)(1-\beta(1-q_S)) = \left(b\bar{z} - \frac{(1-\delta_S)q_L\bar{x}}{1-\tau_S}\right)(1-\beta(1-q_L)) \tag{23}$$

Solving (23) for δ_S yields

$$\delta_S = \frac{\beta b\bar{z}(q_S - q_L) + \frac{q_L}{1-\tau_S}(1-\beta(1-q_L))}{\frac{q_S}{\tau_S}(1-\beta(1-q_S)) + \frac{q_L}{1-\tau_S}(1-\beta(1-q_L))}. \tag{24}$$

This finishes the proof. ■

Proof of Lemma 5:. We first show that both λ_S and λ_L either decrease or increase together whenever τ_S increases. Differentiating $\alpha^S - \alpha^L$ with respect to τ_S yields

$$\frac{d(\alpha^S - \alpha^L)}{d\tau_S} = \frac{\partial \alpha^S}{\partial \lambda_S}\frac{d\lambda_S}{d\tau_S} - \frac{\partial \alpha^L}{\partial \lambda_L}\frac{d\lambda_L}{d\tau_S}.$$

Because $\alpha^S = \alpha^L$ in equilibrium, we have $\frac{d(\alpha^S-\alpha^L)}{d\tau_S} = 0$. Therefore, we have

$$\frac{\partial \alpha^S}{\partial \lambda_S}\frac{d\lambda_S}{d\tau_S} = \frac{\partial \alpha^L}{\partial \lambda_L}\frac{d\lambda_L}{d\tau_S}. \tag{25}$$

Because $\frac{\partial \alpha^h}{\partial \lambda_h}$ is negative, (25) implies that the sign of $\frac{d\lambda_S}{d\tau_S}$ should be identical to that of $\frac{d\lambda_L}{d\tau_L}$.

Next, we show that λ_S increase (or decrease) in τ_S if and only if δ_S/τ_S is greater (or less) than one. To see this, suppose that λ_h increases when τ increases. Then, both λ_S and λ_L should increase together. Because any increase in λ_h must be because of the increase in δ_h/τ_h in reponse to the change in τ_S., we must have

$$\begin{aligned}\frac{\delta_S + \Delta\delta}{\tau_S + \Delta\tau} &> \frac{\delta_S}{\tau_S};\\ \frac{1-\delta_S-\Delta\delta}{1-\tau_S-\Delta\tau} &> \frac{1-\delta_S}{1-\tau_S}.\end{aligned}$$

where $\Delta\delta$ and $\Delta\tau$ are positive constants. This implies both $\frac{\Delta\delta}{\Delta\tau} > \frac{\delta_S}{\tau_S}$, and $\frac{1-\delta_S}{1-\tau_S} > \frac{\Delta\delta}{\Delta\tau}$. Therefore, we have$\frac{1-\delta_S}{1-\tau_S} > \frac{\delta_S}{\tau_S}$, or equivalently, $\frac{\delta_S}{\tau_S} > 1$. We can similarly show for the only if case.

Finally, we find the condition under which δ_S/τ_S is greater (or less) than one in equilibrium. Because α_S monotone decreases in δ_S/τ_S and α_L monotone increases in δ_S/τ_S, we would have $\delta_S/\tau_S > 1$ in equilibrium if $\alpha_S > \alpha_L$ given $\delta_S/\tau_S = 1$, or equivalently,

$$\frac{(1-\frac{q_S\bar{x}}{b\bar{z}})(1-\beta(1-q_S))}{(1-\frac{q_L\bar{x}}{b\bar{z}})(1-\beta(1-q_L))} > 1. \tag{26}$$

or equivalently, we have

$$\frac{\bar{x}}{b\bar{z}} < \frac{1}{q_S + q_L + r_f}. \tag{27}$$

■

Proof of Lemma 3: Standard arguments imply that the IC constraint (5) must bind. Furthermore, it must be that $w_B^{*i} = w_\emptyset^{*i} = 0$ for otherwise shareholders could reduce the wage bill without violating the IC constraint. Hence, an optimal contract solves

$$\min_{\left\{w_G^i, \left\{w_{R_0}^i, w_{R_1}^i, w_{R_2}^i, \ldots\right\}\right\} \in \mathbb{R}_+^{1+\mathbb{Z}^*}} \lambda_h \sigma_1 w_G^i + (1-\lambda_h)\rho_1 q_h \left(\sum_{t=0}^{\infty} (1-q_h)^t \beta^t w_{R,t}^i\right) \tag{28}$$

such that the IC constraint (5) binds,

$$\lambda_h \Delta\sigma u\left(w_G^i\right) + (1-\lambda_h)\Delta\rho q_h \left(\sum_{t=0}^{\infty} (1-q_h)^t \beta^t u\left(w_{R,t}^i\right)\right) = K. \tag{29}$$

Consider the case $\lambda_h > 0$. From the wage bill in (28) we obtain the slope of the isocost curve

$$\frac{dw_G^i}{dw_{R,\tau}^i} = -\frac{(1-\lambda_h)\rho_1}{\lambda_h \sigma_1} (1-q_h)^\tau \beta^\tau. \tag{30}$$

Next, assume $w_G^i > \bar{w}$ (we will later verify that this will be the case for $\bar{w} < \frac{B}{\Delta\sigma}$) and consider separately the cases $w_R^i \geq \bar{w}$ and $w_R^i < \bar{w}$ for an arbitrary date τ. Assume $w_R^i \geq \bar{w}$ first. From the IC (29),

$$\frac{dw_G^i}{dw_{R,\tau}^i} = -\frac{(1-\lambda_h)\Delta\rho}{\lambda_h \Delta\sigma} (1-q_h)^\tau \beta^\tau. \tag{31}$$

Because $\frac{\rho_1}{\sigma_1} > \frac{\Delta\rho}{\Delta\sigma}$, a decrease in w_R^i along the IC constraint leads to a lower isocost curve, which implies that w_R^{*i} never exceeds $\bar{w}$. On the other hand, for $w_R^i < \bar{w}$, (29) gives

$$\frac{dw_G^i}{dw_{R,\tau}^i} = -\frac{(1-\lambda_h)\Delta\rho}{\lambda_h \Delta\sigma\gamma} (1-q_h)^\tau \beta^\tau. \tag{32}$$

Let $\bar{\gamma} \equiv \frac{\sigma_1 \Delta\rho}{\Delta\sigma\rho_1}$. For $\gamma > \bar{\gamma}$, it is again true that a decrease in w_R^i along the IC constraint leads to a lower isocost curve, which implies $w_R^{*i} = 0$ for all τ. Then, solving (29) for w_G^i while setting $w_R^i = 0$ gives (6) in the statement of the lemma. Clearly, in this case the wage bill simplifies to

$$\mathcal{W}_h = \frac{\sigma_1}{\gamma\Delta\sigma}\left(K - \bar{w}\lambda_h (1-\gamma)\Delta\sigma\right), \tag{33}$$

which is linear and decreasing in λ_h. When $\gamma < \bar{\gamma}$, the IC is steeper than the isocost curve, in which case it is optimal to increase w_R^i up to $\bar{w}$ for all τ; solving (29) for w_G^i

while setting $w_R^i = \bar{w}$ gives (7) in the lemma. For $\gamma = \bar{\gamma}$ the IC and the isocost curves are parallel, meaning that any pair satisfying (29) with $w_R^i \leq \bar{w}$ is optimal, including the one in the lemma. Finally, for $\gamma \leq \bar{\gamma}$, the wage bill under the optimal contract satisfies

$$\mathcal{W}_h = \frac{\sigma_1}{\gamma \Delta \sigma} K - \bar{w}\sigma_1 \left(\lambda_h \left(\frac{1}{\gamma} - 1 \right) + (1 - \lambda_h) \frac{q_h}{1 - (1 - q_h) \beta} \left(\frac{\Delta \rho}{\gamma \Delta \sigma} - \frac{\rho_1}{\sigma_1} \right) \right). \quad (34)$$

We have:

$$sign \left(\frac{\partial \mathcal{W}_h}{\partial \lambda_h} \right) = -sign \left(\left(\frac{1}{\gamma} - 1 \right) - \frac{q_h}{1 - (1 - q_h) \beta} \left(\frac{\Delta \rho}{\gamma \Delta \sigma} - \frac{\rho_1}{\sigma_1} \right) \right)$$

and

$$\left(\frac{1}{\gamma} - 1 \right) - \frac{q_h}{1 - (1 - q_h) \beta} \left(\frac{\Delta \rho}{\gamma \Delta \sigma} - \frac{\rho_1}{\sigma_1} \right) \geq \frac{\Delta \sigma \rho_1}{\sigma_1 \Delta \rho} - 1 > 0$$

where the prior to last inequality follows from $\gamma \leq \bar{\gamma}$. Hence, $\mathcal{W}_h$ is strictly decreasing in λ_h under the optimal contract.

Finally, using (6) and (7), it is immediate to verify that $\bar{w} < \frac{B}{\Delta \sigma}$ implies $w_G^{*i} > \bar{w}$, which verifies the initial conjecture.

Next, consider $\lambda_h = 0$. Assume $w_{R,t}^i \geq \bar{w}$ and $w_{R,t+j}^i < \bar{w}$ for some $t \geq 0$ and $j > 0$. The wage bill in (28) gives

$$\frac{dw_{R,t}^i}{dw_{R,t+j}^i} = -(1 - q_h)^j \beta^j,$$

while from the IC (29) we obtain

$$\frac{dw_{R,t}^i}{dw_{R,t+j}^i} = -\frac{(1 - q_h)^j \beta^j}{\gamma},$$

implying that an increase in $w_{R,t+j}^i$ along the IC leads to lower wage bill. A similar argument shows that if $w_{R,t}^i < \bar{w}$ and $w_{R,t+j}^i \geq \bar{w}$ (again for some $t \geq 0$ and $j > 0$) then an increase in $w_{R,t}^i$ along the IC leads to lower wage bill. This implies that either $w_R^i \geq \bar{w}$ for all τ or $w_R^i < \bar{w}$ for all τ, in which case the IC and the isocost are parallel. Hence, a w_R^{*i} that is independent of when the project matures is optimal. It is immediate to verify that $\bar{w} < \frac{K}{\Delta \sigma}$ implies $w_R^{*i} > \bar{w}$ and that (8) solves the IC (29). In this case the wage bill becomes

$$\mathcal{W}_h = \frac{\rho_1}{\gamma\Delta\rho}K - \bar{w}\rho_1\frac{q_h}{1-(1-q_h)\beta}\left(\frac{1}{\gamma}-1\right),$$

which exceeds (33) and (34) valued at $\lambda_h = 0$. ■

Proof of Proposition 3. Note that the l.h.s. of (9) is strictly increasing in τ^*, approaches $-\infty$ (resp. ∞) as τ^* approaches 0 (resp. 1). Because $\mathcal{W}_L - \mathcal{W}_S > 0$ for all τ under the assumptions of Corollary 1, then it follows that (9) has a solution. (Of course, if $\mathcal{C}_S = \mathcal{C}_L$ then the l.h.s. of (9) is symmetric around 0 and therefore $\tau^* > 1/2$.) The remaining part of the argument is given in the main text. ■

References

Aghion, P., J. Van Reenen, and L. Zingales, 2013, "Innovation and Institutional Ownership," *American Economic Review*, 103(1), 277–304.

Bolton, P., J. A. Scheinkman, and W. Xiong, 2006, "Executive Compensation and Short-Termist Behaviour in Speculative Markets," *Review of Economic Studies*, 73(3), 577–610.

Bushee, B. J., 1998, "The Influence of Institutional Investors on Myopic R&D Investment Behavior," *The Accounting Review*, 73(3), 305–333.

Cremers, M., A. Pareek, and Z. Sautner, 2016, "Short-Term Investors, Long-Term Investments, and Firm Value," Working Paper, University of Notre Dame, Rutgers University, and Frankfurt School of Finance and Management.

Gaspar, J.-M., M. Massa, and P. Matos, 2005, "The Influence of Institutional Investors on Myopic R&D Investment Behavior," *Journal of Financial Economics*, 76(1), 135–165.

Giannetti, M., and X. Yu, 2016, "The Corporate Finance Benefits of Short-horizon Investors," Working Paper, Stockholm School of Economics and Indiana University.

Han, J., and F. Sangiorgi, 2015, "Searching for information," Working Paper, Stockholm School of Economics.

Hardin, G., 1968, "The tragedy of the commons," *Science*, 162(3859), 1243–1248.

Hellwig, C., S. Kohls, and L. Veldkamp, 2012, "Information Choice Technologies," *American Economic Review*, 102(3), 35–40.

Holmstrom, B., 1979, "Moral Hazard and Observability," *The Bell Journal of Economics*, 10(1), 74–91.

Holmstrom, B., and J. Tirole, 1993, "Market Liquidity and Performance Monitoring," *Journal of Political Economy*, 101(4), 678–709.

Narayanan, M. P., 1985, "Managerial Incentives for Short-term Results," *Journal of Finance*, 40(5), 1469–1484.

Porter, M. E., 1992, "Capital Disadvantage: America's Failing Capital Investment System," *Harvard Business Review*, 70(5), 65–82.

Shavell, S., 1979, "Risk Sharing and Incentives in the Principal and Agent Relationship," *The Bell Journal of Economics*, 10(1), 55–73.

Sims, C. A., 2003, "Implication of Rational Inattention," *Journal of Monetary Economics*, 50, 665–690.

Stein, J. C., 1989, "Efficient Capital Markets, Inefficient Firms: A Model of Myopic Corporate Behavior," *Quarterly Journal of Economics*, 104(4), 655–669.

Thakor, R. T., 2015, "A Theory of Efficient Short-termism," Working Paper, MIT.

Zeng, J., and G. Strobl, 2016, "The Effect of Activists' Short-Termism on Corporate Governance," Working Paper, Frankfurt School of Finance and Management.