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Firm Lifecycles: Linking Employee Incentives and Firm Growth Dynamics

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Research summary: *While the economic advantages of scale are well understood, implications of the rate of firm growth are arguably less appreciated. Since firms' growth rate influences employees' promotion opportunities, the growth rate can have significant implications for the incentives employees face. Rapid growth, by creating more promotion opportunities, motivates employees to engage in extra-role behaviors that might result in promotion should an opportunity arise. Building on this argument, we develop a formal model linking the design of firms' incentive structure to their rate of growth. The associated dynamics lead to three distinct epochs of firms' lifecycle: rapid growth and high-powered incentives driven by frequent promotion opportunities; moderate growth with infrequent promotion opportunities, but large salary increases contingent on promotion; and finally, stagnant firms with low-powered incentives.*

Managerial summary: *While being innovative can lead to a firm growing quickly, the opposite may also be true. Growing quickly may contribute to a firm's ability to improve its processes. Employees are often a source of process improving ideas. Employees' primary incentive to go "outside the job description" to improve those processes is often promotion. The availability of promotions, however, is linked to the firm's growth rate. Firms that are growing quickly can credibly promise to reward their most innovative employees with promotions. Established and slowly growing firms have fewer opportunities for growth, which gives employees less incentive to go "above and beyond." This can mean that rapid growth can reinforce a firm's competitive advantage.*

Introduction

The Strategy literature has long appreciated the importance of economies of scale in influencing competitive advantage and even firm viability (Porter, 1980). Scale economies have also been argued to imply a positive relationship with innovation (e.g., Klepper, 1996; Cohen & Klepper, 1996a, 1996b), while both popular press and some scholarly studies (e.g., Scherer, 1965; Zenger, 1994) have suggested that large, established enterprises may be relatively less innovative than their younger and faster growing competitors.[1] One reason for this conflict may be the conflation of firm size with firms' growth rate. Clearly, firm scale is itself a consequence of prior growth rates, but the constructs are at the same time distinct, and indeed, empirically have been shown to be negatively correlated (Evans, 1987). Growth is generally a

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[1] It is important to note, however, that the Cohen and Klepper (1996a) argument was made in the context of process innovations, and that they were careful to treat product innovations separately as firms might appropriate the returns from product innovations in a qualitatively different manner, such as the introduction of new products and services to the market, or in some cases, through the licensing of technology to other firms.

consequence of the strength of a firm's competitive advantage and value added. We argue here that growth, in turn, can have implications for the firm's competitive advantage as a result of the impact of firm growth on the firm's ability to motivate and incentivize its employees. Growth creates opportunities for upward motility within an organization. The presence of such opportunities, in turn, provides a motivation for workers to "shine more brightly" than their peers in order to win these promotion tournaments (Lazear & Rosen, 1981; Rosenbaum, 1979).

We explore these issues by examining a setting in which a firm is faced with an opportunity to lower its cost of production through learning. There is a long-standing literature on lowering costs of production by "moving down the learning curve" (Argote, 1999; Arrow, 1962; Levitt, List, & Syverson, 2013; Wright, 1936). This learning, however, does not necessarily happen automatically. It requires concerted effort by employees to understand the production process and the properties that can be improved (Von Hippel & Tyre, 1995), and sharing that knowledge (Argote, 1999). Incentivizing employees to undertake that effort, however, is not a trivial task. Taking the initiative to improve processes is one of a class of tasks that are hard to make a contractible part of a job description (Baker, Gibbs, & Holmstrom, 1994; Williamson, Wachter, & Harris, 1975). In particular, these efforts are typically a collective effort and not readily ascribed to specific individuals (Kline & Rosenberg, 1986). Further, the returns to such efforts may be distant in time and even distant organizationally from the locus of the innovative effort (Levinthal & March, 1993).

In the technical language of the organizational economics literature, these properties can result in a two-sided moral hazard problem in that not only is there the standard issue of unobserved effort [action] on the part of the agent, but the outcome of that effort and its payoff consequences for the organization are not contractible (Gibbons & Roberts, 2013). In practice, process improvements are often treated as "extra-role" behavior to be motivated through subjective performance evaluation (Baker et al. 1994; Williamson et al. 1975) rather than explicit contractual mechanisms. Prendergast (1993) provided a model that suggests that promotions and compensation tied to job categories is an important mechanism by which incentives can be provided in the context of such two-sided moral hazard problems, an argument supported by follow-on empirical work by Strych (2015).

Williamson (1975, p. 79) argued in a similar fashion, suggesting that internal promotion structures have attractive incentive properties as different levels of talent and cooperativeness can be rewarded and noted that "compensation rates in internal labor markets are assigned to jobs and rewards are made contingent on performance through the promotion process." Thus, vying for promotions provides a powerful incentive device, particularly with respect to extra-role behavior that is not explicitly demanded of the employee—the "above and beyond the call of duty" initiatives that contracts cannot require, but which can be critical to firms increasing their productivity. This suggests that the ability to motivate employees to create process improvements can depend on the firm's ability to offer promotions.

Promotion opportunities within firms, in turn, are often linked to the firm's growth rate. As long noted by work in organizational sociology (Stewman, 1975; White, 1970), promotion rates at one level of the organization have a clear connection to rates at lower levels. White (1970) referred to this dynamic as "chains of opportunity." While that line of work takes the rate of promotion (or exit from the organization) as largely exogenous, in a business context, the opportunity structure of promotion is intimately linked to the growth rate of the firm itself (Maister & Lovelock, 1982). For instance, the likelihood of a category manager at a particular Walmart store becoming a store manager, or a store manager becoming a district manager, is strongly linked to the rate of new store openings. As Baker, Jensen, and Murphy (1988) argued: "[an] important problem with promotion-based reward systems is that they require organizational growth to feed the reward system. This means such systems can work well in rapidly growing firms, but are likely to generate problems in slowly growing or shrinking firms."

This relationship between firm growth and employee incentives is well elaborated in Galanter and Palay's 1990 work on the growth dynamics of law firms. They (Galanter & Palay, 1990, pp. 780–781) noted that firms "cannot use simple productivity-based compensation schemes because associates cannot verify the partners' observations of associate productivity […]. To provide both the necessary assurances and incentives for maximum

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effort, the big law firm typically ties the payment of its deferred bonus to the outcome of what we call the 'promotion-to-partner' tournament." Further, they observe that the associates' standing' in such a tournament will be based on a subjective, and not mechanistic, evaluation of the associates' efforts. This incentive scheme, in turn, has important implications for the need and value of growth of the firm as if the law firm is to maintain the same ratio of partners to associates the promotion of some subset of associates to partner requires an exponential growth rate, with the specific value depending on this ratio of partners to associates. Galanter and Palay argued that this link between growth and incentives is an explanation for the increasingly skewed size distribution of law firms resulting from processes of mergers, acquisitions, and dissolutions.

We make a related argument connecting firm growth as a consequence of product market sales and the design of incentives for extra-role efforts that, to an important degree, underlie process improvement within firms. The goal of this article is to present a formal, but intuitive, stylized model of firm growth dynamics that examines the implications of the role of promotions in providing employee incentives and the link between those opportunities and the growth rate of the firm. We model a firm's lifecycle from (a) a small, rapidly growing enterprise to (b) a more established firm of substantial scale and moderate growth rate to (c) an older, large, but slow-growth organization.[2] This growth lifecycle dynamic emerges endogenously from the links among the firm's optimal choice of incentive structure, the employees' response to these incentives, and product market dynamics.

In parallel with this dynamic of firm growth, we model the firm's optimal wage profile over time. By *wage profile*, we refer to the differential salary associated with promotion, which is a cost incurred to incentivize employees. We show that, early on, when the firm is growing fairly rapidly, only a modest increase in wages with promotion is necessary, given the relatively high likelihood of promotion. Later, as the firm achieves greater scale and its rate of growth slows, the likelihood of promotion declines. Therefore, in order to maintain the same incentive power, the firm must make each promotion more attractive, for example, by raising the wage premium for the higher position. However, as highlighted by Klepper's (1996) model of industry dynamics, the returns to more efficient operations increase with a firm's scale of operations. As a result of these joint effects, the firm will choose to increase the reward associated with promotion in this second stage. Finally, in a third epoch of substantial scale but little or no growth, promotion becomes so unlikely that the cost of the wage increase associated with a promotion necessary to incentivize employees becomes prohibitive. Thus, the model implies three distinct stages tied to the firm's growth rate: (a) early-stage, high-growth firms with strong prospects for promotion but modest wage increases with promotion; (b) substantial scale and moderate growth rates with relatively infrequent promotion events, but a large step-up in wages contingent on promotion; and (c) a kind of bureaucratic enterprise in which promotion no longer acts as a meaningful incentive device and workers largely cease being extrinsically motivated to engage in extra-role behaviors.

We show that rapidly growing firms can have a powerful incentive-based advantage. Workers in such enterprises are more motivated to work harder, other things being equal, than employees of less rapidly growing firms who have a lower likelihood of promotion. This finding suggests that early-stage firms benefit from a positive reinforcing dynamic, not of network externalities (Arthur, 1994), but of a "rich get richer" sort of dynamic stemming from the positive effect of product market success on firm incentives and worker motivation.[3] The flip side of this positive reinforcing cycle is, of course, the possibility of a downward spiral in which a slow-growth enterprise ossifies, creating only rare promotion opportunities and resulting in a relatively demotivated workforce that adheres to the work activities that drive their immediate contingent rewards, but are not engaged in the sort of extra-role behaviors that make a firm innovative and successful.

[2] Clearly, not all firms go through such a cycle. We model a firm with a viable cost structure entering a new market and growing within this market. Furthermore, the focus here is not on the sorting out of competitive survival among a population of realized and potential entrants, as in Klepper (1996) and Jovanovic (1982).

[3] Note that this positive reinforcement from a firm's product market success is distinct from Merton's discussion of the "Matthew effect," which is based on the positive reinforcement associated with reputation (Merton, 1968).

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Scholars have begun to explore how the nature of product market competition links to the design of individual level managerial incentives (cf. Bennett, 2013; Gimeno, 1999; Vroom & Gimeno, 2007). This work has highlighted how these managerial incentives impact the strategic interaction among firms. We shift the focus to how stages of the lifecycle of a firm and broader industry might influence incentive design. Process innovation has been shown to be critical in influencing industry dynamics (Klepper, 1996), and further, the incentive to engage in process innovation has been argued to be a function of the firm's scale (Cohen & Klepper, 1996a). Our work pushes on this general line of argument and demonstrates the relationship between growth rates, as well as scale, and the design of incentives to elicit process improvements.

Model

We develop a model that links the firm's competitive position, as represented by its size relative to market demand and its cost level, the nature of the optimal contract design for its employees, and the employees' behavior in response to the given contract. While the individual components of the modeling are kept rather simple, the interplay among them offers some important insights.

Firm's Problem

The firm's problem has multiple components. First, the firm decides its output level based on its current marginal cost. Second, the firm must assess, based on its growth opportunities, whether and to what magnitude it wishes to specify a premium associated with promoting an employee. Finally, based on this reward structure, employees decide whether to exert extra-role effort to lower production costs for the subsequent period. After effort is exerted, possible process improvements are realized, and the cycle begins anew. Immediately below, we lay out the firm's product market problem, and in the subsequent subsection, we consider the employee's incentive problem.

Consider a firm that is a monopolist in the product market facing a simple downward-sloping inverse-demand function with price p and quantity q and with parameters $y, z > 0$:[4]

$$p = y - zq. \tag{1}$$

The firm's marginal revenue is therefore:

$$MR = y - 2zq. \tag{2}$$

We assume that each period t the firm has a constant marginal cost of production c_t, but that this cost may vary over time and has an initial value of $c_0 > 0$. Since Wright (1936), the literature on learning curves has modeled cost reduction as decreasing a firm's marginal cost by a constant percentage $r \in (0, 1)$. The literature has since suggested that learning often doesn't happen automatically through cumulative output, but requires explicit directed effort (Argote, 1999; Von Hippel & Tyre, 1995). Following that literature, in each period, we model the possibility of a process improvement $s_t \in \{0, 1\}$, the likelihood of which we characterize below. We define the marginal cost of production at time t, as a function of whether there was a process improvement in the prior period and the prior cost value as follows:

$$c_t = c_{t-1} (1 - r)^{s_{t-1}} . \tag{3}$$

Further, we define $A(t)$ as the sum of process improvements to date,

$$A(t) = \sum_{x=0}^{t-1} s_x.$$

As a result, we can specify c_t as a function of the sum of process improvements to date and the initial cost c_0:

$$c_t = c(A(t)) = c_0 (1 - r)^{A(t)} . \tag{4}$$

The marginal cost of production includes the regular wages of production employees, but not any additional inducements the firm might choose to offer in order to induce efforts at cost reduction.

[4] The linear demand function is adopted to simply the presentation of the argument. All results below are robust to monopolist with a general downward sloping demand curve. Introducing competing firms would raise additional issues, such as the possibility of preemptive investment in learning as in Lieberman (1987).

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The firm chooses its quantity of production to maximize profit, the quantity that equalizes marginal revenue and marginal cost:

$$y - 2zq_t = c(A) \Rightarrow$$
$$q_t = q\left(c_t\right) = \frac{y - c(A(t))}{2z}. \quad (5)$$

This relationship specifies the firm's quantity and price produced in any given period as a function of the process improvements to date. We assume that the number of employees the firm requires to produce a given output level increases with this output level, and in particular, specify a proportionate relationship such that $n_t\left(q_t, m\right) = \frac{q_t}{m}$.[5] For clarity of notation, we subordinate the dependencies on quantity q_t and labor intensity $\frac{1}{m}$ and refer simply to n_t.

As noted above, the likelihood that the firm reduces its cost of production is a function of employees' incentives to understand and improve the production process. Characterizing the changing rate of process improvements thus depends on modeling the employees' decision problem that is characterized below.

Process Improvements and the Employee's Incentive Problem

As discussed earlier, process improvements are typically the result of many individual efforts from front-line production workers, to industrial engineers, and teams of individuals at both the line and staff level. Furthermore, effort does not guarantee success. The stochastic, cumulative, and coordinated nature of these efforts makes attributing improvement to a single individual very difficult. This not only limits the ability of the firm to recognize effort with explicit contingent rewards, but also limits employees' ability to prove they deserve a bonus if the firm were to renege on such a contract. As such, the firm faces what the literature calls a two-sided moral hazard problem (Baker et al. 1994; Gibbons & Roberts, 2013).

Because the firm cannot force employees to exert effort at improving processes, process improvement work falls outside of the employees' explicit duties, that is, it is "extra-role" effort. For instance, one could imagine a customer service employee writing a canned response that would reduce the time to answer the same question in the future, a factory floor worker staying overtime to organize the tools in such a way that they are more easily accessible in the future, a salesperson working on the weekend to transfer contacts into a searchable database, or a production manager reaching out to a supplier about a possible modification of a component design. All of these tasks go beyond the immediate demands of the employee's job, but reduce the marginal cost of effort later.

The prior literature provides important insights as to how firms can incentivize extra-role effort in the face of two-sided moral hazard. Lazear and Rosen (1981) suggested that promotions may function as lotteries for employees to incentivize effort. Because the firm knows when a process improvement occurs, as it knows its marginal cost of production, the firm can offer an incentive to the set of relevant employees contingent on a process improvement. Thus, while the firm cannot commit to awarding a particular employee, it can commit to offering a prize lottery to the entire set of agents.[6]

We build on Lazear and Rosen (1981), and Prendergast (1993) in modeling the firm's problem of incentivizing employees to improve the production process as a promotion tournament. Employees are modeled as choosing whether to expend extra-role effort $e \in \{0, 1\}$ to potentially improve the process by which they work, which with some probability, will lower the marginal cost of the firm's production in the subsequent period. Employees are assumed to be homogeneous with respect to their ability and their cost of effort χ. We assume that the probability of a process innovation is a function of the efforts of the employees involved.

$$P\left(s_t = 1\right) = \zeta \frac{\sum_{i=0}^{n_t} e_{it}}{n_t},$$

[5] Our results going forward are robust to nonlinear relationships between employees and production as long as the number of employees is strictly increasing in q.

[6] Despite the prevalence of contingent contracts in the literature, as noted by McCue (1996), and Baker, Gibbons, and Murphy (1994), many workers' primary prospect for salary growth comes from raises associated with promotions. Consistent with this, in many instances the outcomes of such efforts lack the objective qualities that would lend themselves to an explicit contingent reward (Baker, Gibbons, & Murphy, 2002).

where e_{it} is the choice of employee i to exert extra-role effort in period t, n_t is the number of employees at period t, and ζ characterizes the marginal product of effort with respect to process improvement.

With ζ specified to be in the range $0<\zeta<1$, the function is such that even if every employee expends extra-role effort, there is no guarantee that a process improvement will result. Without that restriction, we encounter the Mirrlees problem (Mirrlees, 1976), where a lack of improvement would be perfectly indicative of a lack of effort and the firm could punish employees an arbitrarily large amount if no improvement arose. The fact that the number of innovations per period is bounded above at one represents time-compression diseconomies, reflecting the property that there is some cumulative nature to these improvements and that a firm cannot generate all innovations in a single period by spending an arbitrarily large amount (Dierickx & Cool, 1989).

Promotion, in this model, is associated with a "premium" that represents the lifetime discounted value of the promotion. An employee generating the highest observed signal wins the prize, a promotion with lifetime value w. In the event that multiple employees generate the same signal, the firm randomly selects one to receive the promotion. Employees only face the opportunity for promotion in their initial period of employment, which can be interpreted as an "up or out" system with those not promoted exiting the firm or a system in which employees once considered for promotion are no longer consider in the future (Kahn & Huberman, 1988; Prendergast, 1993). Employees, therefore, compete with each other when they simultaneously choose their level of effort to expend. Defining P_i as the probability that the employee i wins if she exerts effort, her expected utility is as follows:

$$E\left[u_i|e_i=1\right] = P_i\left(w-\chi\right) + \left(1-P_i\right)\left(-\chi\right)$$
$$= P_i w - \chi.$$

The probability of winning depends on a focal employee's effort expended as well as that of all of the other employees. All employees choose e_i to maximize their expected utility. Following the Nash assumption that each player maximizes against the set of all other players, each employee takes the strategy of the others as given. Assuming symmetric strategies, we can set $e_i=e_k=e \quad \forall k \neq i$, which implies that the probability of winning conditional on exerting effort is $P_i = P\left(win_i|e_i=1\right) = \frac{\zeta}{n}$. This gives us the familiar Lazear and Rosen (1981) result that employees' choice of their level of work is determined by the value of the premium. Employees will therefore choose their effort level to maximize $E\left[u\right] = e\left(P_i w - \chi\right) = e\left(w\frac{\zeta}{n} - \chi\right)$.

If the firm wishes to elicit extra-role effort on the part of employees, it must offer a reward associated with promotion such that such effort is in the employees' interest. Further, in order to maximize its profits, the firm will offer the minimum value of an incentive compatible promotion premium. For employees to exert effort in equilibrium, it must be the case that free riding is not individually rational.[7] This criterion implies that the marginal increase in one employee's utility from exerting effort, when all other employees are exerting effort as well, must be greater than the cost of that individual effort:

$$w\left[P\left(win|e_i=1, e_j\forall j\neq i\right)\right.$$
$$\left.-P\left(win|e_i=0, e_j\ =1\forall j\neq i\right)\right] \geq \chi \Rightarrow$$
$$w\left[\zeta\frac{1}{n} - \zeta\left(\frac{n-1}{n}\right)\frac{1}{n}\right] \geq \chi \Rightarrow$$
$$w\left[\zeta\frac{1}{n^2}\right] \geq \chi \Rightarrow$$
$$w \geq \frac{\chi n^2}{\zeta}.$$

The minimum premium required to induce effort in equilibrium, as a function of the number of employees in the firm, is $w=\frac{\chi n^2}{\zeta}$. Thus, if the firm wishes to induce extra role effort, it offers a premium of $w=\frac{\chi n^2}{\zeta}$, and $w=0$ otherwise. The question then is when would the firm chooses to induce extra role effort.

Analysis

The closed form expression of the firm's profit, gross of any promotion premium, as a function of improvements to date can be stated as follows:

$$\pi\left(A\right) = \left(p_t - c_t\right) q_t.$$

[7] Note that this condition is sufficient, but not necessary for equilibrium.

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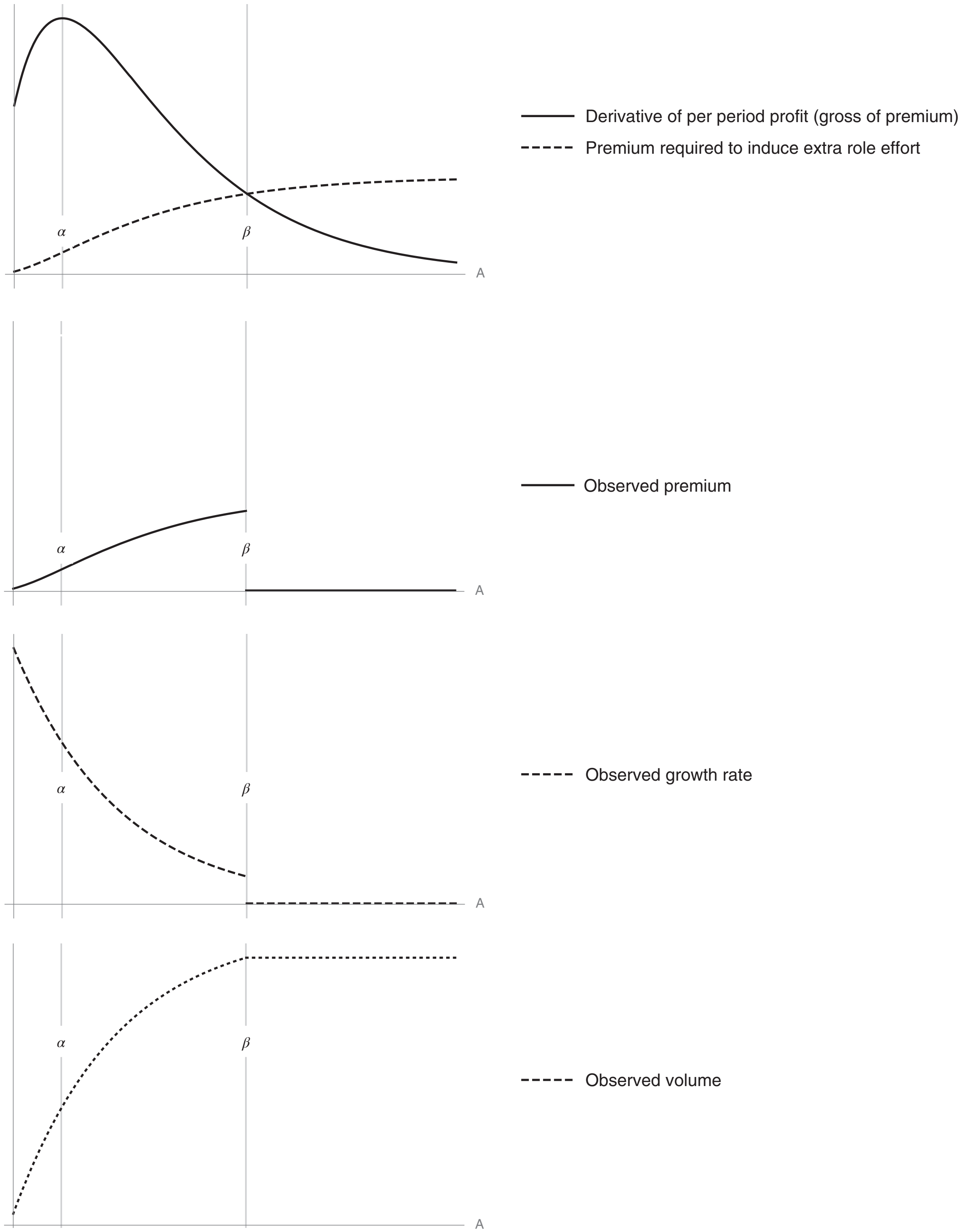

Figure 1. Predicted path of variables. These figures were generated by graphing the closed form expressions derived in Online Supplement 1, in Appendix S1, with the following parametric values: $c = 2.5$, $\zeta = 0.1$, $m = 0.5$, $r = 0.1$, $\chi = 0.0001$, $y = 3$, and $z = 0.2$.

Substituting for q from Equation 5 and for p from Equation 1, yields the following:

$$\frac{\left(y - c_t (1 - r)^A\right)^2}{4z}.$$

Consider the return to an $A+1^{st}$ process improvement. The return to an incremental process improvement is the difference between the discounted current value of future profits after that process improvement and the discounted current value of profits without that process improvement. To highlight the key trade-offs most directly, in the main text, we consider the case of a firm that fully discounts future returns two periods ahead and beyond. This assumption does not qualitatively change the analysis and allows us to think of $\frac{d\pi}{dA}$ as the marginal return to inducing a process improvement. In addition, in Online Supplement 2, in Appendix S1, we establish our core property for case of a firm that maximizes the full dynamic problem with a geometric discount rate. While that specification, including laying out the firm's Bellman equation highlights the dynamic nature of the decision, the results are qualitatively robust to the difference in time-horizon, with the only change being an increase in the number periods for which providing incentives for innovative effort is optimal. For that reason, and simplicity of notation, we present the stationary myopic version here.

To provide some intuition as to how the marginal return to a process improvement changes with the cumulative count of prior process improvements, we illustrate the behavior of the model for a specific set of parameter values in Figures 1–3. Consider the solid curve in the top panel in Figure 1. The return to a process improvement is initially relatively high as the firm is operating at the highest, least efficient, portion of the learning curve. However, the marginal value of a process improvement will generally increase from this initial level. This is due to the effect noted by Klepper (1996), Cohen and Klepper (1996a, 1996b), that process improvements are more valuable to firms operating at a larger scale. The marginal return to process improvement ultimately declines as a result of two forces. One factor is the diminishing effect of further process improvement on marginal cost, as indicated in Equation (4). In the face of a downward-sloping demand curve, there is an additional consideration: decreasing marginal return to further output.[8]

The dashed line in this figure depicts the premium required to induce an additional process improvement as a function of process improvements to date: $w(A) = \frac{\chi n^2}{\zeta} = \frac{\left(\frac{q(A)}{m}\right)^2}{\zeta}\chi$. Given the shape of $w(A)$ and the properties of the returns to process improvement, we see that if a process improvement is ever induced, there will be a succession of process improvements until the point at which the cost of inducing an additional improvement is greater than the benefit. At that point, the firm will cease inducing process improvements and will never induce them again.

Indeed, we are able to establish a general proposition that a wage premium will be offered only if the marginal cost of production is beyond some threshold value.

Proposition 1. *A premium associated with promotion is offered if and only if the marginal cost of production is above some threshold value.*

Proof in the Appendix

Further, as a direct corollary of this proposition, we have the further property:

Corollary 1. *For initial costs, $c_0 > \delta$, we will observe at least two epochs: the premium is offered at first, and then after a threshold value of subsequent process improvements, the premium is no longer offered.*

Proof. This follows immediately from the characterization of the optimum wage premium in Proposition 1. When the initial cost falls below the threshold δ, the first epoch collapses and the firm effectively begins in the second. For initial cost values above this threshold, the initial cost reductions are so valuable that the firm begins in epoch 1.

Returning to Figure 1, we see the minimum premium required to induce process improvements. Recall that this premium operates not so much as compensation for the efforts of managers, but as an

[8] It is worth noting that this third force, the decreasing marginal return to further output, isn't present in the models of Klepper (1996) and Cohen and Klepper (1996a) because in those models there was an assumption that a firm's market-share increases in a manner proportionate to its market-share in the prior period.

inducement for their efforts. We can see that at that point we label β, the cost of inducing improvements and the benefit of doing so, cross. Beyond this point, process improvements will cease.

The bottom three panels of Figure 1 present the variables observable to the econometrician: the premium, theoretically the discounted current value of the wage premium associated with a promotion; the firm's growth rate; and the firm's annual production volume. Note that the top panel's x-axis is represented not by time, but by the number of process improvements to date. This highlights that the passage of time has no intrinsic effect, only the choices of the firm and the possible realization of process improvements. Thus, the threshold β is defined on a scale indicating the number of prior process improvements and not a temporal scale.

The four panels together fully characterize process improvement in the firm's lifecycle in this simple setting. That path of process improvement, in turn, can be tied to the path of the firm's optimal growth rate. Early on, firms will incentivize process improvements that reduce the marginal cost of production. The lower cost of production increases the firm's optimal size and the firm will grow. There comes a point, which we label α, where the marginal value of further process improvement hits its peak and then starts to decline. The marginal value to process improvements is still positive, but slowing growth means that the premium will start to increase at a decreasing rate. Finally, there comes point β at which the returns to process improvement are less than the cost of inducing them, whereupon the firm stops inducing process improvement and growth ceases.

Proposition 2. *If there is a positive premium, it will be negatively related to the firm's growth rate.*

Proof. The second derivative, the growth rate of the growth rate, is negative $\frac{d^2q(A)}{dA^2} < 0$. If the derivative of the premium with respect to improvements is positive, that proves the proposition. The derivative of growth is positive with respect to process improvements $\frac{dq(A)}{dA} > 0$, which implies $\frac{dq(A)}{dA}\frac{w}{m} > 0$, which means the premium is increasing in improvements.

Figure 1 highlights how the above analysis implies that a firm's lifecycle is characterized by the three distinct epochs. In the first epoch, the wage premium associated with a promotion—the premium—is moderate, the growth rate is high, and effort is expended. While the return to process improvement is increasing during this period, it increases at a decreasing rate because of the downward sloping demand curve that restricts the returns to increasing firm scale. There are limits to the firm's desire to grow when customers are willing to pay less and less for each marginal unit. From Figure 1, we can see that a decrease in the firm's rate of growth, which results in a decrease in the probability of promotion, results in the firm having to pay a higher wage premium to induce effort. After the level of accumulated process improvements exceeds the peak of the returns to process improvement curve, the point labeled α, the marginal return to further process improvement begins to decline. As a result, in the second epoch effort is still expended, but the growth rate is more modest and, as a consequence, the wage premium needed to elicit effort increases. The second epoch ends when the firm reaches the level of accumulated process improvements associated with the value β, at which point the cost of inducing effort exceeds its benefit. At that point the firm ceases to encourage extra-role behavior, the employees cease to provide it, and growth also ceases.

Comparative Statics and Additional Analyses

Labor intensity. A critical dimension in our model is the number of promotion opportunities created within the firm when production expands. The parameter m in the model represents the ratio of units of output to employees and can be thought of as how labor-intense the production process is. High values of m indicate low labor intensity, and vice versa. The labor intensity is critical to the link between product market outcomes and individual behavior. One might expect that firms with very labor intensive production processes would have the least improvement generated by employees because there are so many lower level employees competing for promotion. Interestingly, the effect in this model is the opposite. Recall that the firm has $n_t = \frac{q_t}{m}$ production jobs. Higher values of m might be thought of as lower labor intensity–fewer employees per unit of production. This also means, however, that higher values of m indicate that fewer jobs are created when production expands. Extra-role effort will create fewer jobs and less likelihood the focal employee will be promoted. This dulls the

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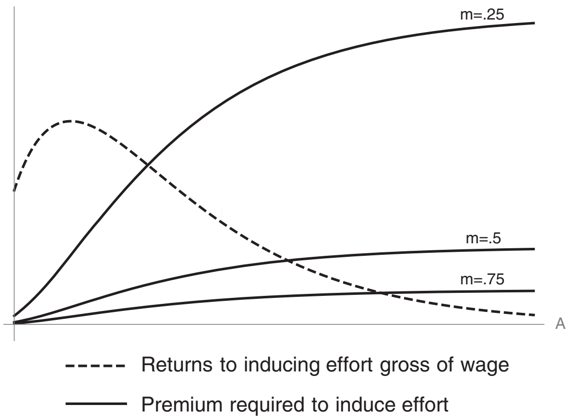

Figure 2. Effect of varying labor intensity. These figures were generated by graphing the closed form expressions derived in Online Supplement 1, in Appendix S1, with the following parametric values: $c=2.5$, $\zeta=0.1$, $m=0.5$, $r=0.1$, $\chi=0.0001$, $y=3$, and $z=0.2$.

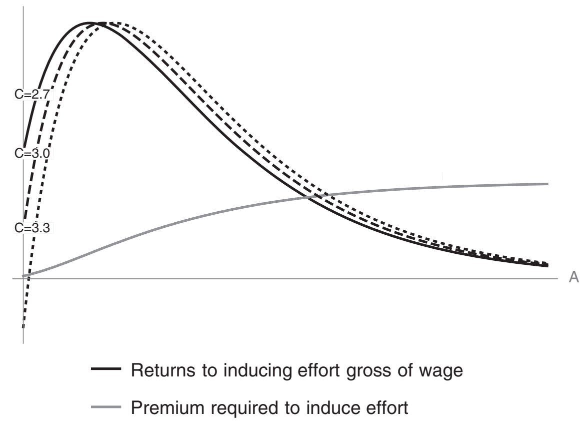

Figure 3. Effect of industry maturity. These figures were generated by graphing the closed form expressions derived in Online Supplement 1, in Appendix S1, with the following parametric values: $c=2.5$, $\zeta=0.1$, $m=0.5$, $r=0.1$, $\chi=0.0001$, $y=3$, and $z=0.2$.

incentive effect of the wage premium. Because of that, firms with low labor intensity need to offer a higher salary premium to motivate production level employees to improve processes. That higher cost of inducing process improvement, in turn, means that process improvement ends sooner. Figure 2 shows how higher values of m, corresponding to lower labor intensity, results in a larger value of β, signifying the point at which the incentive to induce process improvements will cease.

This comparative static draws attention to one of the central contributions of the model. The rate of growth of the firm, not simply its size, has first order implications for the incentives of employees, and by extension, the growth dynamics of the firm.

Industry maturity. One of the critical factors in our model is what one might describe informally as "room for improvement." Traditionally, in the literature on learning curves, industries are viewed as moving from the relatively steep part of the learning curve in which incremental process improvements have significant impact on the firm's productive efficiency to flatter parts of the learning curve where incremental process improvements have little impact on the cost of production. Some firms enter into relatively mature industries where the state-of-the-art technology of production is refined and the industry is farther down the learning curve. Intuitively, in such settings, making contributions to the production technology that will induce profitable growth might be very difficult. Formally, this behavior is captured by the initial marginal cost of production, the c_0 parameter in our model.

Firms entering more mature industries will have low initial marginal costs of production c_0 because accumulated process improvements that have created a more efficient baseline productivity for the industry. In the limit, this means that process improvements will not generate sufficient returns to merit the cost of inducing them. Conversely, firms that enter less mature industries face a greater marginal return to process improvements. Thus, the more mature the industry is, the sooner epoch three arrives and process improvements cease. Figure 3 demonstrates how higher values of c_0, indicating higher initial marginal costs of production and thus lower maturity, extend the time until epoch three.

Conclusion and Discussion

How firms should design their incentive structure is obviously an important issue for managers. Traditionally, scholars have approached this question as an issue as how to elicit the most effort from employees. This approach looks within the firm, without considering the interaction between the employees' work within the firm and factors in the external product market. This model highlights the interaction between incentives within the firm and the firm's opportunities in the product market. We show that growth opportunities in product markets may change the motivational context within the firm, as this internal opportunity

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structure is intimately tied to the firm's market position. By the same token, diminished external opportunities may be a significant demotivating force. The model helps bridge what have been two largely separate "conversations"—the design of internal incentive structure and the dynamics of product markets. Linking these "conversations" is not only a challenge for strategy scholars, but also constitutes a parallel challenge to firms that need to link the design of their HR systems with an understanding of the growth dynamics the firm is likely to experience. Further, given the incentive effects of firm growth illuminated by the modeling, firms have a growth imperative beyond the usual argument in the strategy literature regarding the leverage of existing, possibly underutilized, resources. Finding new opportunities for growth also, as suggested by the model, amplifies employees' incentive to engage in extra-role behavior, which in turn, can enhance the firm's competitive advantage.

As with any model, we have had to choose to highlight certain features and subordinate others. We focus on the issue of growth dynamics. The three qualitatively distinct incentive regimes that we identify—growth, maturity with moderate growth, and stagnation—provide new insight regarding the fundamentally different incentive challenges (and opportunities) that firms face at different points in their development. In this sense, the model highlights the contrasting effects of firm growth and firm size. Growth provides an incentive benefit as a function of the associated heightened promotion prospects. As a result, a given wage premium has more impact on employees' incentives during a period of more rapid growth. Size has two types of effect. On the one hand, it provides a greater incentive to achieve greater efficiency per Klepper (1996). On the other hand, size, as a result of the firm's scale relative to the magnitude of consumer demand, acts to limit the incentives for further growth. At a moderate size level, we see the balance tilt toward the incentive for greater efficiency and firms offer substantial wage premia in connection with promotions to ensure employee effort in the face of the diminished prospects of promotion associated with substantial scale. While efficiency improvements are still desired, as a firm gets larger its growth slows, and the low rate of growth implies low rates of promotion. It would therefore require a very large wage premium to make the prospect of promotion a meaningful incentive. Assuming a fixed demand curve, the firm then reaches stasis: Incentives for innovative efforts are not economical and no extra-role effort is expended.

Core to the focus on growth dynamics is the presence of two-sided moral hazard. Prior work has noted the role of tournaments and promotions as critical mechanisms for addressing two-sided moral hazard with respect to the firm and its employees (Lazear & Rosen, 1981; Prendergast, 1993). Our analysis builds on this core insight and pushes this logic further to make the link between the firm's growth rate, which influences the frequency of promotion opportunities, and this two-sided moral hazard problem. In the absence of two-sided moral hazard, firms and employees are able to make explicit contracts regarding employees' contributions to firm productivity and then direct contingent contracts can suffice. Even in such a setting, there still would remain a relationship between the nature of these contingent contracts and the firm's size and its growth rate, driven by the same three factors of the effect of firm size on the returns to process innovation, the declining impact along the learning curve of incremental process innovations, and the declining marginal revenue to further output growth as a result of a downward slopping demand curve. What would change would be the nature of the second "epoch" in which the wage premium increases with promotion as the likelihood of promotion declines. Rather, we would observe a monotonically declining level of contingent reward for innovative efforts. It is also important to note that our focus is on process innovations. Just as with Cohen and Klepper (1996a), the logic of value creation and appropriation is arguably quite different for product innovations. Product innovations are also less likely to be subject to the two-side moral hazard problem that our analysis addresses.

In order to highlight the interaction of employee-level incentives and firm-level incentives, we have narrowed our focus to a monopoly setting. The monopoly setting comes with two benefits in terms of clarity. First, the dynamics are generated through the changing return to innovation over time. In the monopoly setting the firm is large enough to affect aggregate prices with its production, which tempers the benefits of cost reduction. A similar result could be generated with other structures that have diminishing marginal incentive to innovate. Second, this setting allows us to focus on the firm's problem without focusing on competitive interactions.

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The forces that drive our current results of the relationship between a firm's growth rate and design of managerial incentives would be present in a competitive setting as well. What a competitive setting would add is an additional layer of strategic considerations in which a firm may choose to design incentives to generate some preemptory advantages by attempting to move down the learning curve more rapidly than its competitors (Lieberman, 1987). There is certainly opportunity for future work to enrich the model in a variety of ways, including allowing for heterogeneity of employees as in Jovanovic (1982), heterogeneous strategies by firms like costly entry deterrence, product innovations that shift the demand curve instead of the cost curve, or radical nonincremental innovations.

While possibilities for extensions exist, the core property developed here—the effect of firm growth on incentives—is a basic factor in the design of incentives within firms and points to new lines of inquiry that link market dynamics to the generation of competitive advantage. In that sense, the model suggests a form of positive feedback in which firms whose favorable competitive position allows them to enjoy above average growth will also benefit from high-powered internal incentives. The joint consideration of internal incentive structure, firm growth, and industry dynamics offers potential insight into central questions of competitive advantage and a new basis from which to understand wage structures within firms.

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Supporting Information

Additional supporting information may be found in the online version of this article:

Appendix S1. Online Supplements 1 and 2.

Appendix

Proof of Proposition 1. The fully discounting firm's problem is:

$$\max_{w \in \left\{0, \frac{\chi n^2}{\zeta}\right\}} \pi_t + \beta E_t \pi_{t+1} \tag{A1}$$

with

$$\pi_t \equiv \pi\left(c_t\right) = \frac{\left(y - c_t\right)^2}{4z}$$

and

$$E_t \pi_{t+1} = \begin{cases} \pi\left(c_t\right), & \text{if } w = 0 \\ \zeta\left[\pi\left(c_t(1-r)\right) - w\right] + (1-\zeta,)\,\pi\left(c_t\right) & \text{if } w = \frac{\chi n^2}{\zeta} = \chi\zeta\left(\frac{y-c_t}{2zm}\right)^2 \end{cases}.$$

Because π_t does not depend on w, we can write the condition under which the firm will offer a wage premium for a promotion as

$$\zeta\left[\pi\left(c_t(1-r)\right)-w\left(c_t\right)\right]+(1-\zeta)\,\pi\left(c_t\right)\geq\pi_c\left(c_t\right)$$
$$\Longleftrightarrow\qquad \pi\left(c_t(1-r)\right)-\pi\left(c_t\right)\geq w\left(c_t\right)$$
$$\Longleftrightarrow\qquad \frac{\left(y-c_t(1-r)\right)^2}{4z}-\frac{\left(y-c_t\right)^2}{4z}$$
$$\geq\frac{\chi}{\zeta\,(2zm)^2}\left(y-c_t\right)^2$$
$$\Longleftrightarrow g\left(c_t\right)\equiv-\left(r(2-r)+\frac{\chi}{\zeta zm^2}\right)c_t^2$$
$$+2y\left(r+\frac{\chi}{\zeta zm^2}\right)c_t-\frac{\chi}{\zeta zm^2}y^2\geq 0.$$

Given that $g(0)<0$, $g'(0)>0$, and the discriminant of g is positive, this quadratic has two roots in $\mathbb{R}_{++}$. These two roots can be solved for using the quadratic formula:

$$\frac{y}{\left(r(2-r)+\frac{\chi}{\zeta zm^2}\right)}\left(r+\frac{\chi}{\zeta zm^2}\pm r\sqrt{1+\frac{\chi}{\zeta zm^2}}\right).$$

Call the two solutions δ^- and δ^+. We can verify that the larger of the two, δ^+ is greater than y:

$$\frac{y}{\left(r(2-r)+\frac{\chi}{\zeta zm^2}\right)}\left(r+\frac{\chi}{\zeta zm^2}\pm r\sqrt{1+\frac{\chi}{\zeta zm^2}}\right)>y$$
$$\Longleftrightarrow r+\frac{\chi}{\zeta zm^2}+r\sqrt{1+\frac{\chi}{\zeta zm^2}}>r(2-r)+\frac{\chi}{\zeta zm^2}$$
$$\Longleftrightarrow r\sqrt{1+\frac{\chi}{\zeta zm^2}}>r(1-r)$$
$$\Longleftrightarrow\qquad\frac{\chi}{\zeta zm^2}>-r(2-r).$$

The final implication is always true. This allows us to focus only on the smaller of the two roots, δ^-. The optimal premium w^*, as a function of cost, is zero for costs below δ^- and the minimum necessary to induce effort above that:

$$w^*\left(c_t\right)=\begin{pmatrix}0 & \text{if } c_t\in[0\delta^-]\\ \frac{\chi}{\zeta(2zm)^2}\left(y-c_t\right)^2 & \text{if } c_t\in\left[\delta^-,y\right]\end{pmatrix}.$$

Recall that $c_0\in[0,y]$. This means that if $c_0\in[0,\delta^-]$, the firm will never induce process improvement. Whenever $c_t\in[\delta^-,y]$, the firm will induce effort. That means that when $c_0\in[0,\delta^-]$, the firm will begin by inducing effort and the provide the higher premium continuously until $c_t>\delta^-$.

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