Letting Go: Managerial Incentives and the Reallocation of Capital*

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Abstract

This paper studies the provision of incentives to reallocate capital when managers are reluctant to relinquish control and have private information about the productivity of assets under their control. We show that when managers get private benefits from running projects substantial bonuses are required to induce managers to declare that capital under their control is less productive and should be reallocated. When aggregate productivity and hence the number of projects is low and fewer managers are required to run projects such bonuses would leave managers with unnecessary rents. This means that it is more costly to induce reallocation and thus less capital is reallocated. From the investor's perspective, capital is more illiquid in bad times since too much of the gains from capital reallocation would accrue to managers.

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1 Introduction

Why is it hard to redeploy capital in bad times? In this paper we argue that reallocation is costly in bad times because it is tough to get managers to relinquish control and release assets.

We study a model where investors need to hire managers to run projects. Managers privately observe the productivity of capital under their control and need to be given incentives to reveal it to enable productive reallocation. But managers get private benefits from control and hence need to be compensated for the loss in private benefits when they relinquish control in order for them to have an incentive to announce their productivity truthfully. Thus, reallocation requires paying large bonuses to unproductive managers. This may not be in the interest of shareholders when the expected compensation necessary to hire managers is low, since it would imply leaving managers with unnecessary rents. From the investor's perspective, capital is more illiquid in bad times since too much of the gains from capital reallocation would accrue to managers. Thus, in bad times, when expected compensation of managers is low because there are fewer projects to run and hence managers are less scarce, investors optimally induce less reallocation.

The procyclical nature of capital reallocation has been documented in Eisfeldt and Rampini (2003).[1] We also show there that, in contrast, the benefits to reallocation, measured as the cross-sectional dispersion of the productivity of capital, appear countercyclical. This suggests that the frictions impeding reallocation are considerably countercyclical. Accordingly, we illustrate the apparent countercyclical nature of capital illiquidity using a model with costly capital reallocation calibrated to match these two observations along with the standard business cycle facts. However, the cost of reallocation in that paper is exogenously specified. Instead, in this paper we examine a specific reallocation friction, namely, the agency problem be-

[1]Related findings about the business cycle properties of capital reallocation can be found in, for example, Maksimovic and Phillips (2001), who show that the fraction of plants which change hands per year is higher in expansion years than in recession years. There is also an extensive literature on mergers and merger waves (see, e.g., Andrade, Mitchell, and Stafford (2001) and Holmström and Kaplan (2001) for recent surveys). For a more detailed discussion of the empirical literature see Eisfeldt and Rampini (2003).

tween owners and managers. Capital reallocation may be costly from an investor's perspective because any gains from trade must be split with managers. The larger the fraction of the gains accruing to managers, the less likely investors are to choose to induce reallocation.

We argue that the contracting friction of having to provide managers with incentives to relinquish control results in countercyclical reallocation frictions. While there is an extensive literature on the interaction between informational and contracting frictions and aggregate economic conditions,[2] the focus of this literature is on the impact of these frictions on new investment rather then on the reallocation of existing capital.[3] Notice that, unlike in the case of new investment, countercyclical credit constraints per se do not necessarily imply procyclical reallocation. While a potential buyer of capital might be less able to acquire capital when he is more credit constrained, a potential seller of capital might be more eager to sell to free up resources since he, too, is more credit constrained. Thus, since reallocation always implies investment by one party and disinvestment by another, it is not obvious what countercyclical credit constraints imply about the cyclical properties of reallocation.

In our model, managers need to be rewarded for sharing bad news early. Relatedly, Harris and Raviv (1990) study the role of debt when "managers are reluctant to relinquish control and unwilling to provide information that could result in such an outcome." In a similar spirit, Levitt and Snyder (1997), in a study of the flow of information within organizations, show that "to elicit early warning, contracts must reward agents for coming forward with bad news."[4] Clearly, there is considerable

[2]See, for example, Bernanke and Gertler (1989), Kiyotaki and Moore (1997), and Rampini (2004).

[3]Exceptions which explicitly consider the reallocation of existing assets include Shleifer and Vishny (1992), who study the impact of the value of assets which are reallocated on debt capacity ex ante, and Eisfeldt (2004), who shows that the amount of adverse selection in the market for existing assets might vary countercyclically and hence reduce reallocation in bad times. An alternative to reallocating capital or projects themselves is to reallocate the funds required for investment across borrowers instead. This problem has been studied more extensively in the literature, e.g., by Holmström and Tirole (1998) and Caballero and Krishnamurthy (2001). See also Gorton and Huang (2002), who allow for both reallocation of funds and projects.

[4]See also Povel (1999), who argues that "it may pay if the creditors are forgiving in bankruptcy, thereby inducing the revelation of difficulties as early as possible."

controversy over paying big bonuses to people who are leaving their jobs in the popular press. Paying bonuses to someone who will no longer affect the firm's prospects seems gratuitous. In fact, providing insurance for the manager amounts to rewarding poor performance and thus has adverse incentive effects. But these bonuses serve an important purpose by providing incentives to the managers to reveal bad news about productivity early, in time to enable productive reallocation.[5]

Boot (1992) also considers the incentives of managers to divest capital. He studies the role of takeovers in a model where unskilled managers might be reluctant to divest projects which are unproductive in their hands, because this would partially reveal their lack of ability. Almazan and Suarez (2003) study the role of severance pay and managerial entrenchment in optimal replacement decisions of CEOs. Finally, Mehran, Nogler, and Schwartz (1998) investigate CEOs' incentives to liquidate their firms empirically and conclude that the extent of CEOs' incentive compensation, in terms of the fraction of shares held by the CEO and the exposure of the CEO through options, increases the probability of voluntary liquidations.[6] These papers focus on the divestment decisions of a single firm. Our paper builds on the intuition developed in these papers in order to study how the microeconomic contracting friction between owners and managers interacts with macroeconomic conditions to affect aggregate capital reallocation.

The paper proceeds as follows. Section 2 discusses the problem of a representative investor providing incentives for managers to relinquish control and reallocate capital in a model with three dates. Section 3 studies the problem of a representative investor in a dynamic infinite horizon economy where the within period incentive problem is as described in Section 2 in order to examine the implied business cycle properties for capital reallocation. A calibrated version of the model is also provided. Section 4 concludes.

[5]Our model abstracts from the ex ante incentive cost of bonuses received by unproductive managers. This tradeoff has been considered by Levitt and Snyder (1997) and Povel (1999).

[6]Murphy (1999) surveys the literature on executive compensation. Hite, Owers, and Rogers (1987) and Kim and Schatzberg (1987) document that interfirm asset sales and voluntary corporate liquidations seem to imply a value-improving reallocation of resources.

2 Incentives for Relinquishing Control

In this section we study the problem of a risk averse representative investor who has access to projects and has the means to finance them, but does not have the skill to run the them. Thus, the investor must hire managers to run any projects in which he chooses to invest. Managers get private benefits from the capital under their control. Furthermore, managers privately observe at an intermediate date whether capital under their control will be productive or not. At the intermediate date, capital can also be reallocated across managers. In this section we study the one period problem of hiring managers and providing them with incentives to declare the productivity of capital under their control truthfully and to agree to the redeployment of the capital prior to production if desirable. In the next section, we will embed this problem in a dynamic model in which an infinitely lived risk averse representative investor has to hire one period managers to run projects in order to study the effect of this agency problem on capital reallocation over the business cycle.

2.1 Environment

Consider a one period economy with three within period dates 0, 1/2, and 1, which we will refer to as "spring," "summer," and "fall," respectively, in the dynamic economy in the next section.

Investor. There is a representative investor with preferences over date 1 consumption c, $u(c)$, where u is assumed to be strictly increasing and strictly concave. The investor has access to a continuum of identical production technologies which require an initial investment of k units of capital as well as a manager each. In this section, we will assume that the investor has a total of $K = k$ units of capital at date 0. Hence the investor hires measure one of managers to operate measure one projects.

Managers. There is a continuum of managers with Lebesgue measure on $\mathbb{R}_+$. Managers vary in their cost of effort e where $e \in [0, \infty)$ and we assume that if measure $\bar{m}$ of managers gets hired, the effort cost of the marginal manager is $\bar{e} = e(\bar{m})$ where $e(m)$ is increasing and convex in m. Thus, the cost of hiring managers increases as more managers get hired. In this section, since aggregate capital $K = k$,

$\bar{m} = 1$. While effort is observable and hence managers who are hired all exert effort, the cost of effort is unobservable. Thus, to get $\bar{m}$ managers to participate, the managerial compensation contract has to satisfy the marginal managers participation constraint.[7] We normalize the reservation utility of all managers to $\underline{u} = 0$.

Managers are ex ante identical except for their cost of effort e. At date 1/2, managers observe whether the productivity of capital under their control is high, a_H, or low, a_L, where $a_H > a_L$, with probability π and $1-\pi$, respectively. Productivity is independent and identically distributed across managers. Capital reallocation occurs after managers realize their productivity and announce their type. A manager of type s who announces type $\hat{s}$ and who deploys $k_{\hat{s}}$ units of capital after reallocation produces $a_s k_{\hat{s}}$ consumption goods at date 1 depending on their productivity a_s, where $s, \hat{s} \in \{H, L\}$. Hence, productivity is not embedded in the capital itself, but is determined by who deploys it.[8] Output at date 1 is observable by both managers and the investor. There is no output at date 1/2.

In addition, managers get private benefits from running a project in the amount of $bk_{\hat{s}}$ if they have an amount of capital $k_{\hat{s}}$ under their control at date 1.[9] Private benefits are not in terms of the consumption good and can not be seized. Finally, managers have limited liability, i.e., their compensation in consumption goods can not be negative.

To summarize, the timing is as follows: At date 0, the investor hires measure $\bar{m} = 1$ of managers and gives them k units of capital each. At date 1/2, the managers observe the productivity of capital under their control and announce their produc-

[7]Notice also that there is no alternative mechanism that would reduce expected compensation while providing managers with incentives to announce their effort cost truthfully. All managers prefer more expected compensation to less and thus they can capture the entire quasi-rent.

[8]See Eisfeldt and Rampini (2003) for a similar assumption and a discussion of the supporting microeconomic evidence.

[9]The distribution of private benefits will determine how the cost of reallocation varies with the amount of capital reallocated. To simplify the analysis here, we assume all projects yield the same private benefits, and that all managers extract private benefits in an identical way. In practice, there is variation in the associated private benefits of projects and managers. We note that if, as in our model, the amount of private benefits is observable, all else equal projects and managers with low private benefits will be reallocated first, and the cost will be increasing in the amount of capital reallocated.

tivity to the investor, and capital is reallocated if the investor so chooses. At date 1, output is produced, payments are made, and managers obtain the private benefits from capital under their control. Figure 1 describes the timing of the contracting problem of this section.

In this section we take aggregate capital K and hence the measure of required managers $\bar{m}$ and the effort cost of the marginal manager $\bar{e}$ as given. In Section 3, aggregate capital will be determined by the investor's dynamic consumption and investment problem. The effect of aggregate productivity on the investor's choices will provide a link between capital reallocation and the business cycle.

2.2 Contracting Problem

Denote the amount of capital deployed after reallocation by a manager who announces type s truthfully by k_s, $s \in \{H, L\}$, and the dividend paid by that manager to the investor by d_s. Also, denote the dividend paid by a manager of type s who announces type $\hat{s} \neq s$ by $d_{\hat{s}s}$. The representative investor's utility maximization problem is as follows:

$$\max_{k_H, k_L, d_H, d_L, d_{LH}, d_{HL}} u(c)$$

subject to a participation constraint for the marginal manager,

$$\pi\{(a_H + b)k_H - d_H\} + (1 - \pi)\{(a_L + b)k_L - d_L\} - \bar{e} \geq 0,$$

two incentive compatibility constraints,

$$\begin{aligned} (a_H + b)k_H - d_H &\geq (a_H + b)k_L - d_{LH} \\ (a_L + b)k_L - d_L &\geq (a_L + b)k_H - d_{HL}, \end{aligned}$$

two resource constraints,

$$\begin{aligned} \pi d_H + (1 - \pi)d_L &\geq c \\ k &\geq \pi k_H + (1 - \pi)k_L, \end{aligned}$$

as well as non-negativity and limited liability constraints

$$\begin{aligned} k_s \geq 0, \forall s \in \{H, L\} \\ a_s k_s - d_s \geq 0, \forall s \in \{H, L\} \\ a_s k_{\hat{s}} - d_{\hat{s}s} \geq 0, s \neq \hat{s}, \forall s, \hat{s} \in \{H, L\}. \end{aligned}$$

Notice that we have used the fact that the investor does not face any aggregate risk in the one period economy since project returns are independent. We have also assumed that given their type, all managers are treated symmetrically, i.e., they deploy the same amount of capital and make the same payments.

We start by characterizing the solution when the participation constraint does not bind. We show that, depending on parameter values, there are two possible solutions to the contracting problem: either there is no reallocation or all the capital in the hands of managers with low productivity is reallocated. The interesting case is the one in which there is no reallocation when the participation constraint doesn't bind and we restrict attention to this case. We then show that, when the participation constraint binds, the investor chooses to provide incentives for managers who announce low productivity to reallocate some capital, but not necessarily all of it.

In fact, we show that the amount of reallocation is increasing in the expected compensation that managers require (and hence in the effort cost of the marginal manager). If the effort cost of the marginal manager is low enough that the participation constraint does not bind, then the investor chooses no reallocation. Thus, for low $\bar{m}$ there is no reallocation. The higher is the cost of effort of the marginal manager, the (weakly) more reallocation the investor chooses. Once the participation constraint binds, reallocation is increasing in $\bar{m}$ until full reallocation is reached.

Consider the case in which the participation constraint is not binding. It is intuitive that if capital is reallocated at all, it is reallocated from the less productive managers to the more productive managers, i.e., that $k_H \geq k_L$. Since all of the constraints are linear, there are only two cases to consider. Either there is no reallocation or there is full reallocation.

No reallocation means that both types of managers deploy the same amount of capital $k_H = k_L = k$. If there is no reallocation, it is as if capital is deployed at the average productivity and the payoff to the investor is $(\pi a_H + (1 - \pi)a_L)k$. All managers get to deploy their original k units of capital and hence they each get a payoff of bk, all of which accrues in private benefits.

Full reallocation means that managers who announce that their productivity is low relinquish control and deploy no capital whereas managers who announce that their productivity is high deploy both their initial capital as well as the capital that is reallocated. Thus, managers with high productivity deploy k/π units of capital each and obtain private benefits of bk/π. This is only incentive compatible if managers with low productivity obtain a sufficiently high bonus. In fact, the bonus to managers with low productivity has to be bk/π. Why? A manager with low productivity who announces high productivity gets to deploy k/π units of capital instead of none and would hence get a payoff in terms of benefits from control of bk/π instead of zero. The manager would get no additional pay since the investor observes output at date 1 and will seize all of it given that the manager has deviated. But this means that the manager with low productivity can obtain a payoff of bk/π by deviating and thus the bonus required equals bk/π. Notice that the bonus to the low productivity manager needs to be paid in consumption goods, unlike the payoff to the high productivity manager which accrues in private benefits. The expected payoff to the managers is hence $(\pi)(bk/\pi) + (1-\pi)(bk/\pi) = bk + \frac{1-\pi}{\pi}bk$ where the first term on either side is expected private benefits (which a fraction π of managers will receive since they realize high productivity) and the second term is expected bonuses to relinquish control (which a fraction $(1-\pi)$ will receive since they realize low productivity). Thus, the investor's payoff is $a_H k - \frac{1-\pi}{\pi}bk$ since all capital is deployed at the high productivity but bonuses need to be paid out of consumption goods to induce managers to relinquish control and reallocate capital.

This discussion is summarized in the following proposition which is proved in the appendix.

Proposition 1 *Assume the participation constraint does not bind. Then either (i) there is no reallocation and the investor's payoff is $(\pi a_H + (1-\pi)a_L)k$ and managers get a payoff of bk, or (ii) there is full reallocation and the investor's payoff is $a_H k - \frac{1-\pi}{\pi}bk$ and managers get a payoff of $bk + \frac{1-\pi}{\pi}bk = bk/\pi$.*

Notice that this implies a surplus, i.e., a sum of the investor's payoff and the payoff to managers, when there is no reallocation of $(\pi a_H + (1-\pi)a_L)k + bk$ and when there is full reallocation of $a_H k + bk$. Since $a_H > a_L$, reallocation is always efficient, i.e., $a_H k + bk > (\pi a_H + (1-\pi)a_L)k + bk$, but it may not be in the interest of the investor since part of the gains accrue to the managers. The interesting case is where the investor prefers not to induce reallocation when the participation constraint does not bind. Using the investor's payoffs under no and full reallocation, we assume in the remainder of the paper that:

Assumption 1 $\pi a_H + (1-\pi)a_L > a_H - \frac{1-\pi}{\pi}b$.

The payoffs for the investor and the manager described in Proposition 1 for the case in which Assumption 1 is satisfied are graphed in Figure 2 (the point labeled "NR" refers to the no reallocation payoffs and the point labeled "R" to the full reallocation payoffs).

Proposition 1 describes the solution assuming that the participation constraint does not bind. We now consider the fact that the participation constraint may bind. First, we claim that if $\bar{e}$ is sufficiently low then the participation constraint in fact does not bind. To see this, note that when $\bar{e} \leq bk$, if the participation constraint is ignored, the program is solved by the investor choosing no reallocation since this maximizes his payoff. The payoff associated with this choice also satisfies the managers' participation constraint, so no reallocation is the solution.

For higher $\bar{e}$, the participation constraint binds and the amount of reallocation depends on the effort cost of the marginal manager. If the effort cost of the marginal manager is sufficiently high, namely if $\bar{e} = bk + \frac{1-\pi}{\pi}bk$, then the investor will choose the full reallocation solution (the point labeled "R" in Figure 2). Indeed, for $\bar{e} \geq bk + \frac{1-\pi}{\pi}bk$, the investor will choose to induce full reallocation. The intuition is that for high $\bar{e}$ managers need to be compensated so highly that the promised compensation in consumption goods exceeds $\frac{1-\pi}{\pi}bk$, which is the expected bonus required to induce full reallocation by the low productivity managers. Since promised compensation exceeds the "cash" bonus necessary to induce low productivity managers to release capital, the incentive problem is solved. In this range, agency costs are zero and it is free to induce managers to reveal their productivity truthfully, given that their promised compensation exceeds the necessary bonus. Note, however, that for these high values of $\bar{e}$ the investor's payoff is reduced by the additional compensation necessary to get managers to participate. Full reallocation maximizes total surplus and is efficient. However, ignoring the participation constraint it does not maximize the investor's payoff. As a larger fraction of capital is reallocated, more and more of the total surplus must be assigned to the managers. Thus, the investor only chooses to reallocate if the managers require a large fraction of the surplus simply to agree to participate in managing the projects.

For intermediate values of $\bar{e}$ inducing partial reallocation of capital is optimal, and the fraction of reallocation is increasing in $\bar{e}$ (see the line connecting points "NR" and "R" in Figure 2). The following proposition characterizes the solution formally in this case:

Proposition 2 *Suppose Assumption 1 holds. Then: (i) If $\bar{e} \leq bk$, there is no reallocation and the payoffs are in part (i) of Proposition 1. (ii) If $bk < \bar{e} < bk/\pi$, there is partial reallocation and the payoff to the investor is $\pi \frac{\bar{e}}{bk} a_H k + \left(1 - \pi \frac{\bar{e}}{bk}\right) a_L k - (\bar{e} - bk)$ while the managers get $\bar{e}$. (iii) If $bk/\pi \leq \bar{e}$, there is full reallocation and the investor's payoff is $a_H k - (\bar{e} - bk)$ and the payoff to the managers is $\bar{e}$.*

If $bk < \bar{e} < bk/\pi$, there is thus partial reallocation and in this case the payoff to the investor can also be written as

$$\left(1 - \frac{\pi}{1-\pi} \frac{\bar{e} - bk}{bk}\right) \left(\pi a_H + (1-\pi) a_L\right) k + \frac{\pi}{1-\pi} \frac{\bar{e} - bk}{bk} \left(a_H - \frac{1-\pi}{\pi} b\right) k.$$

The interpretation of this expression is that only a fraction $\frac{\pi}{1-\pi} \frac{\bar{e}-bk}{bk}$ of managers are given incentives to reallocate capital if their productivity is low (which implies a return to the investor of $a_H k - \frac{1-\pi}{\pi} bk$ on this capital) while fraction $1 - \frac{\pi}{1-\pi} \frac{\bar{e}-bk}{bk}$ of managers are not given incentives to reallocate (and thus the return on this capital is $\left(\pi a_H + (1-\pi) a_L\right) k$). The interpretation of the expression in the proposition is that managers are induced to reallocate only part of their capital such that, after partial reallocation, a fraction $\pi \frac{\bar{e}}{bk}$ of capital is deployed at the high productivity and the rest at the low productivity. The two expressions are equivalent.

When there is partial reallocation, the amount of capital reallocation R is

$$R \equiv \pi \frac{\bar{e} - bk}{bk} k.$$

Thus, capital reallocation is increasing in $\bar{e}$ in this range. Agency costs AC measured as the amount of output lost due to the asymmetry of information about productivity are

$$AC = \left(1 - \pi \frac{\bar{e}}{bk}\right) \left(a_H - a_L\right) k$$

in this range and are decreasing in $\bar{e}$. For $\bar{e} \leq bk$, there is no reallocation and agency costs are constant at $(1-\pi)(a_H - a_L)k$. Likewise, for $\bar{e} \geq bk/\pi$, reallocation is equal to the amount of capital held by low productivity managers, $(1-\pi)k$, and agency costs are zero. This is because managers must be paid so much that the bonus necessary to reallocate all capital from unproductive to productive managers is within their required compensation.

The economic intuition of our model of managerial incentives and the reallocation of capital is as follows: An increase in $\bar{e}$ means that expected compensation of managers increases which is clearly costly for the investor and reduces his payoff. However, the good news is that the more managers make, the easier it is to provide the bonuses required to induce them to relinquish control. All that is required is to give managers the extra compensation, which needs to be paid in consumption goods, as a "cash" bonus for relinquishing control when they declare low productivity. Thus, as $\bar{e}$ increases, the amount of capital which is reallocated and hence the amount of capital deployed at the high productivity increases. In the next section, we use the contracting problem developed here in a dynamic economy to study the business cycle properties of capital reallocation.

3 Capital Reallocation and the Business Cycle

In Eisfeldt and Rampini (2003) we have shown that capital reallocation is procyclical while productivity dispersion is not. In this section we use our model of incentives for relinquishing control from the previous section in a dynamic environment to explain why there may be less reallocation in bad times. Our model suggests that it may be too expensive to get managers to release assets when productivity is low and hence managers' expected compensation is low. When managers' required compensation is low, the bonuses necessary to induce managers to relinquish control would leave them with additional rents and this is not in the interest of the investor. Loosely speaking, such bonuses would imply "overpaying" managers by too much in bad times. These bonuses result in too much of the gains from reallocation accruing to the managers and so the investor chooses not to reallocate capital.

3.1 Environment

Consider an infinite horizon discrete time economy with periods $0, 1, 2, \ldots$. Each period has three seasons, "spring," "summer," and "fall," which correspond to dates 0, 1/2, and 1 in the previous section. The within period problem is essentially unchanged from section 2.

The investor is infinitely lived and has preferences

$$E\left[\sum_{t=0}^{\infty} \beta^t u(C_t)\right]$$

where $\beta < 1$, C_t is consumption at time t, and u is strictly increasing and strictly concave. The investor starts the spring of every period with output Y_{t-1} and capital K_{t-1} in hand and observes the aggregate productivity Ω_t. Given these, the investor chooses in the spring how much of the output to consume, C_t, and how much to invest in capital I_t, and then consumes and invests. The investor then has to hire one period managers to manage the aggregate amount of capital implied by his investment decision, $K_t = K_{t-1}(1-\delta) + I_t$. At the start of a project, each manager can manage at most k units of capital, thus measure $\bar{m}_t = K_t/k$ of managers need to be hired. Managers live for one period and hence the contracting problem is the same as in Section 2. In summer, managers observe their idiosyncratic productivity (i.e. the productivity of capital if it is under their control), declare it to investors, and capital is reallocated. In fall, output is produced, and managers obtain private benefits from capital under their control, get paid, and consume. Any payoff that accrues to the investor in fall gets carried over to the spring of the next year to be consumed or invested at that time. Figure 3 describes the timing of a single period of the infinite horizon economy.

In this economy, both aggregate and manager specific productivity varies. As before, capital under the control of any given manager has either a high productivity $a_{H,t}$ or a low productivity $a_{L,t}$, $a_{H,t} > a_{L,t}$, with probability π and $1-\pi$, respectively. Conditional on the aggregate state, projects are identically and independently distributed. However, in the dynamic economy each manager's productivity has two components, an aggregate component Ω_t and an idiosyncratic component $\omega_{s,t}$. Aggregate productivity Ω_t shifts managers' productivities as follows: $a_{H,t} = \Omega_t + \omega_H$

and $a_{L,t} = \Omega_t + \omega_{L,t}$ where $\omega_{H,t} = \omega_H$ and $\omega_{L,t} = \omega_L$. Finally, aggregate productivity follows a Markov chain with transition probability matrix Π. Recall that the timing is such that in the spring of period t, the investor and managers observe the aggregate productivity of capital for that year Ω_t while the managers observe the idiosyncratic productivity of capital under their control $(a_{s,t})$ only once summer arrives.

The timing was chosen such that the contracting problem of Section 2 is identical to the within period contracting problem in the dynamic economy. Furthermore, the timing assumptions imply that the risk neutral managers can not bear any aggregate risk and thus do not provide insurance for the risk averse investor. Aggregate productivity for period t, Ω_t, is observed in the spring before managers are hired and thus managers can not provide insurance about Ω_t. In addition, managers get paid and consume in the fall of the same year and thus can not provide insurance about aggregate productivity for the next period, Ω_{t+1}, either. Thus, there is no resolution of aggregate uncertainty within the duration of the contract.

3.2 Investor's Problem

The investor's problem can now be written recursively as follows. Consider the investor's problem in the "spring." The investor has K_{-1} units of capital and Y_{-1} units of output carried over from last period. The investor also observes aggregate productivity for this period, Ω. Given these three state variables (K_{-1}, Y_{-1}, Ω), he decides how much to consume now, C, and how much to invest in capital, I, to solve:

$$V(K_{-1}, Y_{-1}, \Omega) = \max_{C,I} u(C) + \beta E[V(K, Y, \Omega')]$$

subject to

$$\begin{aligned} Y &= A(\Omega, K)K \\ Y_{-1} &\geq C + I \\ K &= K_{-1}(1-\delta) + I \end{aligned}$$

where

$$\begin{aligned} A(\Omega, K) \equiv \Omega &+ \left(1 - \frac{\pi}{1-\pi}\frac{\bar{e}(K/k) - bk}{bk}\right)(\pi\omega_H + (1-\pi)\omega_L) \\ &+ \frac{\pi}{1-\pi}\frac{\bar{e}(K/k) - bk}{bk}\left(\omega_H - \frac{1-\pi}{\pi}b\right). \end{aligned}$$

for $bk < \bar{e}(K/k) < bk/\pi$,

$$A(\Omega, K) \equiv \Omega + (\pi\omega_H + (1-\pi)\omega_L)$$

for $\bar{e}(K/k) \leq bk$, and

$$A(\Omega, K) = \Omega + \omega_H - \frac{\bar{e}(K/k) - bk}{k}$$

for $\bar{e}(K/k) \geq bk/\pi$. The investor's problem is well-behaved. The production function $A(\Omega, K)K$ is weakly concave in K since productivity is weakly concave in $\bar{e}$ and $\bar{e}(\bar{m})$ is convex in $\bar{m} = K/k$ by assumption. The contracting problem in Section 2, which is graphed in Figure 2, determines $A(\Omega, K)$, which in turn determines how much output the investor can get out of the capital he owns. Thus, the within period agency problem between the investor and the managers is reflected in the aggregate "productivity" $A(\Omega, K)$ at which the investor can deploy capital. Considering managerial incentives in the decision to reallocate capital leads to endogenously determined "productivity."

3.3 Calibration

We calibrate our model to be consistent with standard business cycle stylized facts for the capital output ratio, the investment rate, and the standard deviation of log output, investment, and consumption. We use standard preference and technology parameters where possible. Finally, we ensure that the reallocation rate, or the fraction of capital reallocated each year, is consistent with that in Compustat and reported in Eisfeldt and Rampini (2003). Table 1 summarizes the calibration.

For preferences, we choose $\beta = 0.96$ and $\sigma = 2$. We set depreciation δ to 0.1. Individual project size k is normalized to one. Managers are equally likely to realize high and low productivity each period. Aggregate productivity follows a symmetric two state Markov chain, with, for example, the probability of remaining in the high productivity state if productivity is currently high equal to 0.75. Aggregate productivity is 0.4 on average and has a standard deviation of 1.25%. Manager specific shocks have zero mean and a standard deviation of 12.5% of aggregate productivity. Thus, idiosyncratic risk is an order of magnitude larger than aggregate risk, which is empirically plausible.

Since our model incorporates agency costs and private benefits, our calibration necessarily involves some parameters which are difficult to calibrate. We tie our hands somewhat by matching the facts discussed above, in particular the fraction of capital reallocated every year. Furthermore, Assumption 1 restricts private benefits relative to productivity and technology parameters. For private benefits b we chose 0.2, which satisfies this assumption given our choices for technology parameters. Finally, we need to specify $\bar{e}(m)$. We assumed in Section 2 that $\bar{e}$ was increasing and convex in m, which ensures that the production function is concave. Since $km = K$ and $k = 1$, $m = K$ and we can simply specify $\bar{e}$ as a function of aggregate capital, K. We specify $\bar{e}$ to be a linear function of aggregate capital which implies no reallocation at the lower bound of our discretized state space, and full reallocation at the upper bound.[10]

Clearly, direct measures of private benefits may be hard to come by. The cyclical properties of managerial compensation, however, should be easier to measure. Murphy (1999), in a survey of the executive compensation literature, documents many stylized facts about the cross section of executive compensation as well as a substantial increase in the level of compensation for the years 1992 to 1996 largely due to grant-date value of stock option grants. However, we are not aware of a direct estimate of the cyclical component of executive compensation. The limited use of relative performance evaluation and indexation in compensation contracts provides at least indirect evidence that overall executive compensation is procyclical.

3.4 Results

We start by verifying that our calibration is consistent with the standard business cycle facts and then discuss the implications for reallocation. The simulation results are summarized in Table 2. A depreciation rate δ of 0.1 directly implies an investment to capital ratio of 0.1 since the model is stationary. Furthermore, the unconditional

[10] Consider the expression for the fraction of managers who are given incentives to reallocate capital which follows Proposition 2. No reallocation implies that $\frac{\pi}{1-\pi}\frac{\bar{e}-bk}{bk}$ equals zero and full reallocation implies that this fraction equals one. We assume that there is no reallocation at the lower bound of the state space, say K_{min}, so that $\bar{e}(K_{min}/k) = bk$, and that there is full reallocation at the upper bound, say K_{max}, so that $\bar{e}(K_{max}/k) = bk/\pi$.

average of Ω was calibrated to 0.4 because this would imply a capital output ratio of 1/0.4=2.5 if reallocation and the cost of hiring managers were ignored. Of course, this is only approximately the case when the endogeneity of $A(\Omega, K)$ is taken into account, which is influenced by both the amount of capital and agency costs in equilibrium. The capital to output ratio in the model then turns out to be 2.563, which is empirically plausible. Finally, the standard deviation of aggregate productivity of 1.25% implies a standard deviation of log output of 1.39%, a standard deviation of log consumption of 1.00%, and a standard deviation of log investment of 3.40%. These are broadly consistent with the data and comparable to the predictions of the standard real business cycle model.

We now turn to the implications for reallocation. First, in terms of the reallocation to capital ratio or reallocation rate, our calibration implies a reallocation rate of 3.24% which implies a reallocation to (gross) investment ratio of 24.47%. These numbers are comparable to the estimates we obtained using Compustat data in Eisfeldt and Rampini (2003), namely 23.89% for the reallocation to investment ratio and between 1.75% and 5.52% for the reallocation rate. Second, our model of countercyclical reallocation frictions implies that the amount of reallocation is considerably procyclical. The contemporaneous correlation of log reallocation and log output is 0.450. The corresponding number in the data is 0.637 for the correlation between the cyclical component of log reallocation and the cyclical component of log output.[11] Figure 4 plots a simulation of the reallocation rate, aggregate output, aggregate capital, and aggregate productivity over one hundred years in this economy. Reallocation is clearly positively correlated with output (top and second graph) and procyclical. Naturally, output is high when aggregate productivity is high and the aggregate capital stock is large. Moreover, a larger fraction of capital is reallocated during these times since more managers are needed to manage the large capital stock and as a result managers' compensation accommodates the bonuses needed to induce reallocation. Thus, our model of managerial incentives and capital reallocation generates a considerable amount of procyclical variation in reallocation. We conclude that the reluctance of managers to relinquish control generates countercyclical

[11] See Eisfeldt and Rampini (2003), Table 2, for details.

reallocation frictions and results in procyclical capital reallocation.

4 Conclusions

We show that when managers are reluctant to let go, i.e., reluctant to relinquish control and release assets, capital reallocation can be considerably procyclical, consistent with stylized empirical facts. We consider the problem of providing managers with incentives to announce that the capital under their control should be redeployed elsewhere when the productivity of capital in their hands is low and show that this requires that bonuses be paid to unproductive managers. When aggregate productivity is high and managers are scarce, managerial compensation is high and hence these bonuses are easily accommodated. In contrast, when aggregate productivity is low and managerial talent is more abundant, paying these bonuses would imply paying managers more than otherwise necessary. This may not be in the interest of the investor and hence the investor may choose not to induce otherwise productive reallocation in bad times. Thus, the managerial agency problem implies countercyclical reallocation frictions and as a result capital is, on average, less productively deployed in bad times.

Appendix

Proof of Proposition 1. First, notice that without loss of generality $d_{LH} = a_H k_L$ and $d_{HL} = a_L k_H$ since otherwise d_{LH} and d_{HL} could be raised which would relax the constraints. Thus, the incentive constraints can be combined and written as

$$a_L k_L - d_L \geq b(k_H - k_L) \geq d_H - a_H k_H. \tag{1}$$

Also recall that the left most term is non-negative and the right most term is non-positive due to limited liability.

Second, we claim that $k_H \geq k_L$. For suppose to the contrary that $k_H < k_L$, then $a_H k_H - d_H > 0$ and $(a_L + b)k_L - d_L > bk_H$. Consider the following perturbation of the allocation of capital $\Delta k_H > 0 > \Delta k_L$ such that $\pi \Delta k_H + (1-\pi)\Delta k_L = 0$. In addition, change the payments by $\Delta d_H = a_H \Delta k_H$ which satisfies the limited liability (LL) constraint and $\Delta d_L = a_L \Delta k_L$ which satisfies both the incentive compatibility (IC) constraint and LL for type L. This allows for a change in the payoff to the investor of $\Delta c = \pi a_H \Delta k_H + (1-\pi) a_L \Delta k_H > 0$ since more weight is put on the positive term of the perturbation with zero expected value. Note also that the change in the participation constraint (PC) is $\Delta PC = 0$. This would be a feasible and incentive compatible improvement, a contradiction.

Now suppose that neither IC constraint holds with equality. Then it must be the case that $d_H = a_H k_H$ and $d_L = a_L k_L$ since otherwise d_H and d_L could be raised. But then the high type's IC constraint implies $bk_H > bk_L$ and the low type's $bk_L > bk_H$, a contradiction. Thus, at least one of the IC constraints must be satisfied with equality.

Next we show that it can not be the case that only the high type's IC constraint is satisfied with equality. Suppose that were the case, i.e., suppose that $(a_H + b)k_H - d_H = bk_L$ and $(a_L + b)k_L - d_L > bk_H$. If $a_H k_H - d_H = 0$, then type H's IC constraint implies $k_H = k_L$ and type L's IC constraint in turn implies $a_L k_L - d_L > 0$. But then it would be possible to raise d_L and improve the objective and thus $a_H k_H - d_H > 0$. Now rewriting H's IC constraint we have

$$(a_H + b)k_H - d_H = bk_H + (a_H k_H - d_H) > bk_H \geq bk_L$$

which means that H's IC constraint does not hold with equality, a contradiction.

Suppose both IC constraints hold with equality. Then

$$0 \leq a_H k_H - d_H = b(k_H - k_L) = d_L - a_L k_L \leq 0$$

which implies that $k_H = k_L = k$ and $d_H = a_H k_H$ and $d_L = a_L k_L$. The investor's payoff in this case is $c = (\pi a_H + (1-\pi)a_L)k$ and the managers' payoff bk. This is the no reallocation allocation. Note that for the participation constraint to be slack this requires that $\bar{e} < bk$.

Suppose that only the low type's IC constraint is satisfied with equality, i.e., $(a_L + b)k_L - d_L = bk_H$ and $(a_H + b)k_H - d_H > bk_L$. Since the participation constraint does not bind, it must then be the case that $a_H k_H - d_H = 0$ since otherwise d_H could be raised. But then, by H's IC constraint $k_H > k_L$. Also, if $a_L k_L - d_L = 0$ this would imply $k_H = k_L$ and $a_H k_H - d_H > 0$, which is impossible, and hence $a_L k_L - d_L > 0$. Thus, $d_H = a_H k_H$ and $d_L = a_L k_L - b(k_H - k_L)$ and the payoff to the investor is $c = \pi a_H k_H + (1-\pi)(a_L k_L - b(k_H - k_L))$. Notice that the objective is essentially linear and hence that either k_H or k_L is zero, where the former is impossible since $k_H > k_L$. Hence, $k_H = k/\pi$ and $k_L = 0$ which implies payoffs of $a_H k - \frac{1-\pi}{\pi} bk$ to the investor and $bk + \frac{1-\pi}{\pi} bk$ to the managers'. This is the full reallocation allocation. □

Proof of Proposition 2. If the participation constraint does not bind, the no reallocation allocation solves the contracting problem given Assumption 1. The no reallocation allocation from Proposition 1 satisfies the participation constraint if and only if $\bar{e} \leq bk$. This establishes part (i) of the proposition. Thus, the participation constraint binds if and only if $\bar{e} > bk$.

Consider the case where the participation constraint binds. By the same arguments as in the proof of Proposition 1, we have $d_{LH} = a_H k_L$ and $d_{HL} = a_L k_H$, and $k_H \geq k_L$. Also, again following the proof of Proposition 1, if both incentive compatibility constraints were satisfied at equality, then $k_h = k_L = k$, $d_H = a_H k_H$, and $d_L = a_L k_L$. But then the managers' payoff would be $bk < \bar{e}$ which would violate the participation constraint. Thus, at most one IC constraint can hold with equality.

Suppose H's IC constraint holds with equality, i.e., $(a_H + b)k_H - d_H = bk_L$ and hence $(a_L + b)k_L - d_L > bk_H$. If $a_L k_L - d_L = 0$, then type L's IC constraint implies $bk_L > bk_H$ which is impossible. Thus, $a_L k_L - d_L > 0$. Consider $\Delta k_H > 0 > \Delta k_L$

such that $\pi\Delta k_H + (1-\pi)\Delta k_L = 0$. This relaxes H's IC constraint and satisfies L's IC and both types' LL constraints and is feasible unless $k_L = 0$. It is then possible to increase d_H by $\Delta d_H > 0$ and improve the objective. If $k_L = 0$, then $k_H = k/\pi$ and H's IC constraint would be slack, a contradiction. Thus, H's IC constraint can not hold with equality.

Suppose both IC constraints are slack. Suppose further that $k_L > 0$. Consider $\Delta k_H > 0 > \Delta k_L$ such that $\pi\Delta k_H + (1-\pi)\Delta k_L = 0$, and $\Delta d_H = a_H \Delta k_H$ and $\Delta d_L = a_L \Delta k_L$. Such a perturbation does not affect the participation constraint $\Delta PC = 0$ and improves the objective by $\pi a_H \Delta k_H + (1-\pi)a_L \Delta k_L > 0$. Thus, $k_L = 0$ and $k_H = k/\pi$. The participation constraint implies that

$$\bar{e} = \pi\{(a_H+b)k_H - d_H\} + (1-\pi)\{(a_L+b)k_L - d_L\} \geq \pi b k_H + (1-\pi)\{(a_L+b)k_L - d_L\} > b k_H,$$

where the first inequality is implied by H's LL constraint and the second by L's IC constraint. Thus, both IC constraints can be slack only if $\bar{e} \geq bk/\pi$ and there is full reallocation in this range. This establishes part (iii).

Finally, for $bk < \bar{e} < bk/\pi$, L's IC constraint must be satisfied at equality. Since the participation constraint together with H's LL constraint and L's IC constraint imply that $\bar{e} \geq b k_H$, k_L can not be zero. Otherwise, $k_H = k/\pi$ and $\bar{e} \geq bk/\pi$, a contradiction. Thus, $k_L > 0$.

Now suppose $a_H k_H - d_H > 0$. Consider $\Delta d_H > 0 > \Delta d_L$ such that $\pi\Delta d_H + (1-\pi)\Delta d_L = 0$. Then there exists $\Delta k_H, \Delta k_L$ such that $\Delta k_H > 0 > \Delta k_L$, $\pi\Delta k_H + (1-\pi)\Delta k_L = 0$, and $(a_L + b)\Delta k_L - \Delta d_L \geq b\Delta k_H$. But this would relax the participation constraint by $\pi a_H \Delta k_H + (1-\pi)a_L \Delta k_L > 0$ and thus d_H could be further increased, a contradiction. Thus, $a_H k_H - d_H = 0$. The participation constraint then implies that $b k_H = \bar{e}$. Furthermore, $k_L = \frac{k}{1-\pi} - \frac{\pi}{1-\pi}\frac{\bar{e}}{b}$, $d_H = a_H \frac{\bar{e}}{b}$, and d_L can be determined using the participation constraint. Thus, the payoff to the investor is $c = \pi \frac{\bar{e}}{bk} a_H k + \left(1 - \pi\frac{\bar{e}}{bk}\right) a_L k - (\bar{e} - bk)$. This completes the proof of part (ii). □

References

Almazan, Andres, and Javier Suarez (2003). "Entrenchment and Severance Pay in Optimal Governance Structures." *Journal of Finance* 58, 519-547.

Andrade, Gregor, Mark Mitchell, and Erik Stafford (2001). "New Evidence and Perspective on Mergers." *Journal of Economic Perspectives* 15, 103-120.

Bernanke, Ben, and Mark Gertler (1989). "Agency Costs, Net Worth, and Business Fluctuations." *American Economic Review* 79, 14-31.

Boot, Arnoud W. A. (1992). "Why Hang on to Losers? Divestitures and Takeovers." *Journal of Finance* 47, 1401-1423.

Caballero, Ricardo J., and Arvind Krishnamurthy (2001). "International and domestic collateral constraints in a model of emerging market crises." *Journal of Monetary Economics* 48, 513-548.

Eisfeldt, Andrea L. (2004). "Endogenous Liquidity in Asset Markets." *Journal of Finance* 59, 1-30.

Eisfeldt, Andrea L., and Adriano A. Rampini (2003). "Capital Reallocation and Liquidity." Working Paper, Northwestern University.

Gorton, Gary, and Lixin Huang (2002). "Liquidity, Efficiency and Bank Bailouts." Working Paper, University of Pennsylvania.

Harris, Milton, and Artur Raviv (1990). "Capital Structure and the Informational Role of Debt." *Journal of Finance* 45, 321-349.

Hite, Gailen L., James E. Owers, and Ronald C. Rogers (1987). "The Market for Interfirm Asset Sales. Partial Sell-offs and Total Liquidations." *Journal of Financial Economics* 18, 229-252.

Holmström, Bengt, and Steven Kaplan (2001). "Corporate Governance and Merger Activity in the U.S.: Making Sense of the 80's and 90's." *Journal of Economic Perspectives* 15, 121-144.

Holmström, Bengt, and Jean Tirole (1998). "Private and Public Supply of Liquidity." *Journal of Political Economy* 106, 1-40.

Kim, E. Han, and John D. Schatzberg (1987). "Voluntary Corporate Liquidations." *Journal of Financial Economics* 19, 311-328.

Kiyotaki, Nobuhiro, and John Moore (1997). "Credit Cycles." *Journal of Political Economy* 105, 211-48.

Levitt, Steven D., and Christopher M. Snyder (1997). "Is no News Bad News? Information Transmission and the Role of 'Early Warning' in the Principal-agent Model." *RAND Journal of Economics* 28, 641-661.

Mehran, Hamid, George E. Nogler, and Kenneth B. Schwartz (1998). "CEO Incentive Plans and Corporate Liquidation Policy." *Journal of Financial Economics* 50, 319-349.

Murphy, Kevin J. (1999). "Executive Compensation." In: Orley Ashenfelter and David Card, Eds., *Handbook of Labor Economics*, Vol. 3b, Amsterdam, The Netherlands, Elsevier Science North Holland, 2485-2563.

Povel, Paul (1999). "Optimal 'Soft' or 'Tough' Bankruptcy Procedures." *Journal of Law, Economics, and Organization* 15, 659-684.

Rampini, Adriano A. (2004). "Entrepreneurial Activity, Risk, and the Business Cycle." Forthcoming, *Journal of Monetary Economics*.

Shleifer, Andrei, and Robert W. Vishny (1992). "Liquidation Values and Debt Capacity: A Market Equilibrium Approach." *Journal of Finance* 47, 1343-66.

Table 1: Parameter Values for Calibration

Preferences						
			β	σ		
			0.96	2		
Technology						
δ	Ω_H	Ω_L	ω_H	ω_L	π	k
0.1	0.4+0.005	0.4-0.005	0.05	-0.05	0.5	1

Private Benefits	Discretized State Space
b	K
0.2	[4.3 : 0.005 : 7]

Table 2: Simulation Results

Panel A: Capital, Output, Investment, and Consumption	
Ratios	
$E[K]/E[Y]$	2.563
$E[I]/E[K]$	0.100
Standard Deviations	
$\sigma(\ln(Y))$	1.39%
$\sigma(\ln(I))$	3.40%
$\sigma(\ln(C))$	1.00%

Panel B: Reallocation	
Ratios	
$E[R]/(E[I]+E[R])$	24.47%
$E[R]/E[K]$	3.24%
Correlation	
$\rho(\ln(R), \ln(Y))$	0.450

Figure 1: Timeline for 3 Date Economy

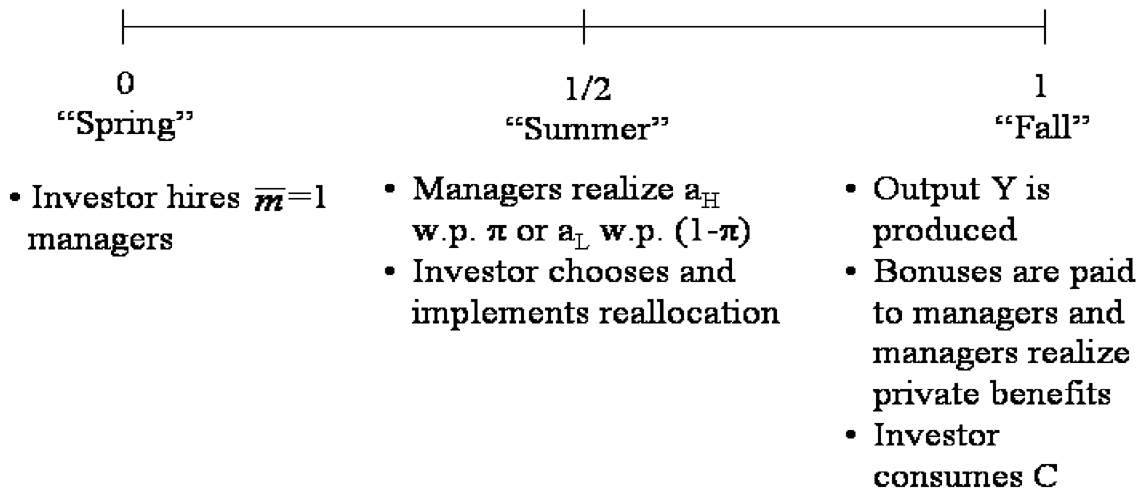

Figure 2: Payoffs to Managers (x Axis) and the Investor (y Axis)

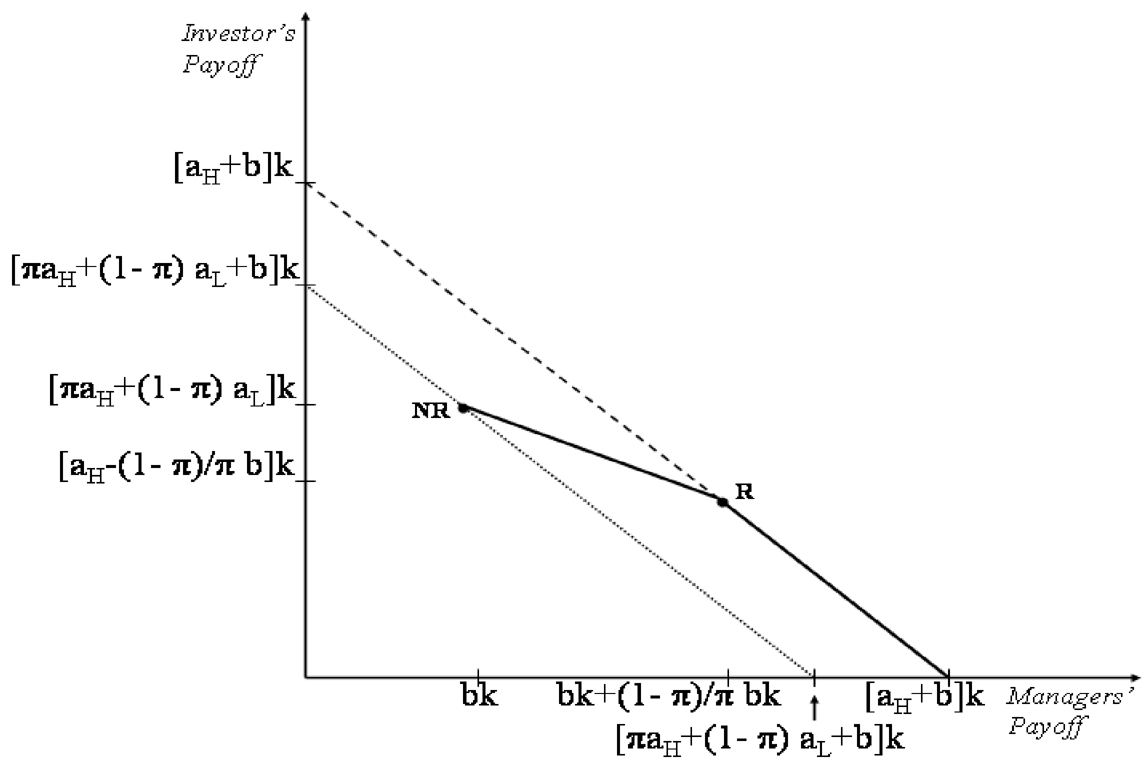

Figure 3: Timeline for Infinite Horizon Economy

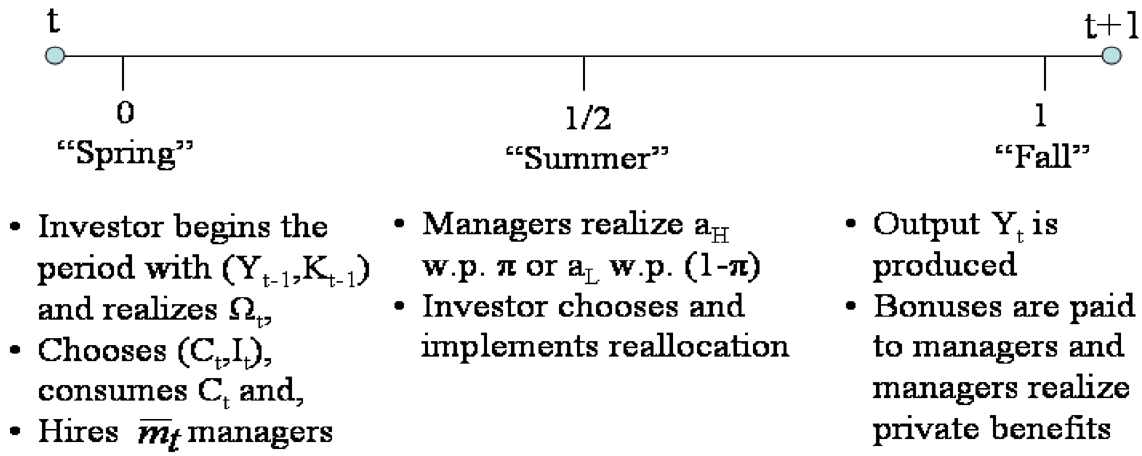

Figure 4: One Hundred Years of Capital Reallocation

Top graph plots the capital reallocation rate, second graph plots aggregate output, third graph plots aggregate capital and bottom graph plots aggregate productivity.