Growth, Selection and Appropriate Contracts*

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Abstract

We study a dynamic model where growth requires both long-term investment and the selection of talented managers. When ability is not ex-ante observable and contracts are incomplete, managerial selection imposes a cost, as managers facing the risk of being replaced tend to choose a sub-optimally low level of long-term investment. This generates a trade-off between selection and investment that has implications for the design of optimal contractual institutions. Our analysis shows that rigid long-term contracts sacrificing managerial selection may be optimal at early stages of economic development, when capital is scarce and access to information limited. As the economy grows, however, capital accumulation increases the return to talent and makes it optimal to adopt flexible contractual relationship, where managerial selection is implemented even at the cost of lower investment. Better institutions, in the form of a richer contracting environment and less severe informational frictions, speed up the transition to short-term relationships. Thus, appropriate contracts evolve endogenously along the process of economic development.

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1 Introduction

Economic growth requires both incentives to undertake projects that pay out in the future and an efficient mechanism to select the best managers to run them. There is no need to stress that avoiding myopic strategies is often crucial for economic success. To motivate long-term investment, it is thus important that managers have sufficient prospects to be among those who will enjoy the future returns. At the same time, however, it is well documented that bad managerial quality can impose large costs. Having the flexibility to remove incompetent managers and workers may thus be essential too. The role of contracts and institutions regulating production relationships is to strike a balance between these possibly conflicting goals.

To study these issues, this paper proposes a model where economic performance depends both on long-term investment and the selection of managerial talent. When ability is not ex-ante observable and contracts are incomplete, managerial selection imposes a cost, as managers facing the risk of being replaced tend to choose a sub-optimally low level of investment. This introduces a trade-off between selection and investment. The aim of this paper is to study this trade-off, how it evolves with the level of development and the availability of information, and its implications for the design of appropriate contractual institutions. It will offer an explanation for why countries at early stages of economic development may start with rigid, long-term, contractual arrangements that sacrifice managerial selection, but will eventually switch to more flexible short-term relationships. Thus, the paper will show how appropriate contractual institutions may change endogenously over the development process.

Our analysis is motivated by both empirical and theoretical considerations. There is ample evidence that contractual institutions and production relationships differ markedly across countries and time. For example, state owned and family firms, that are typically characterized by long-term relationships and very low managerial turnover, tend to prevail at earlier stages of economic development. While some authors have argued that such rigid arrangements are inefficient, others have suggested that they may simply reflect the need for different institutional forms at various stages of development.[1] In particular, Kuznets (1966, 1973) and Gerschenkron (1962) have forcefully stressed that economic growth is accompanied by a process of structural

[1] See, for example, Burkart et al. (2003), Caselli and Gennnaioli (2005) and references therein.

transformation that includes changes in production relationships and an increasing importance of skills. In this spirit, we propose a theory where long-term production relationships may be a second-best arrangement in countries with low levels of human and physical capital, and with limited access to information. As capital is accumulated, however, skills become more important and more flexible short-term contracts arise.

In our baseline model, firms last for two periods and produce output by combining a broad form of capital with managerial skill. In the first period of the life of a new firm, investors hire a manager to run it. Ability is drawn randomly, it is specific to the firm-manager match and observed neither by the manager nor by the investors. Motivated by our desire to study countries at different stages of development, we assume that contracts between investors and managers are incomplete and can only take a simple form. In particular, contracts cannot be made contingent on outcomes and managerial compensation is determined through ex-post bargaining. Under these assumptions, investors only have the choice between offering one-period or two-period employment contracts.

The manager receives the existing capital stock and decides its allocation between current production and a long-term investment that produces new capital in the next period. At the end of the first period, investors observe the level of production, that depends on (1) the allocation of capital, (2) managerial ability and (3) an idiosyncratic shock (noise), and form expectations on the ability of the manager. Next, if investors have signed a one-period contract, they decide whether to confirm the manager (if her expected ability is high enough) or to replace her with a new random draw. In the second period, past investment pays out and production takes place. After that, a new cycle starts again. In sum, investors try to retain managers of above average ability, but only observe a noisy signal of ability. Managers, on the other hand, choose long-term investment in order to maximize their own payoff, that depends positively on the cash flow and the probability of being confirmed.

With this simple model, we first study the determinants of long-term investment. Under flexible one-period contracts, there are two distortions inducing managers to choose a sub-optimally low level of investment. First, the mere possibility of being dismissed implies that managers may not be able to enjoy future returns and this reduces their expected benefit from investment. Second, if investors can only observe current economic performance and not the allocation of capital, managers have an incentive to give up some long-term investment in favor of activities with an immediate payoff in an effort to manipulate the perception of their ability and increase the probability of being retained. This distortion is similar to the one arising in the career concerns' models (e.g., Holmstöm, 1999 and Dewatripont et al. 1999). Both distortions depend on the fact that managers face a non zero probability of being replaced. Hence, they represent the costs of being able to retain good managers and replace incompetent ones. The benefit of selection, on the other hand, is that it ensures on average higher managerial ability.

Next, we turn to study how this trade-off between selection and investment shapes the optimal choice of contracts. More precisely, we ask under what circumstances long-term (two period) contracts sacrificing managerial selection may be welfare enhancing. We find that rigid contracts are optimal when information is very noisy, ability is concentrated and the capital stock of the economy is low. These are cases in which selection is either difficult or not very useful, while investment is relatively more valuable. It is then preferable to maximize investment, even at the cost of lower managerial quality. The model thus suggests long-term contracts to prevail in developing countries with a low capital stock and poor access to information.[2] As capital is endogenously accumulated, however, managerial ability, which is complementary to capital, becomes relatively more important than investment and short-term contracts implementing selection become optimal. Interestingly, we find that this transition is faster in countries with better institutions in the form of a richer contracting environment and less severe informational frictions.

Our paper contributes to the theoretical literature, still in its infancy, on appropriate institutions and growth.[3] To our knowledge, only a few papers study how contractual relationships change with economic development. The closest paper to ours is Acemoglu, Aghion and Zilibotti (2006). They assume that skill is more important for innovation than for the adoption of foreign technologies and find that selection becomes more useful as countries get closer to the technology frontier. They then use the model to study implications for competition policy. Our analysis is com-

[2] However, long-term contracts may also be optimal in societies that are very homogeneous. Japan may provide an interesting example.

[3] This literature has been pioneered by the works of Douglas North (see, for example, North, 1994). Among others, recent contributions focusing on economic institutions are Rodrik (2007), Acemoglu, Aghion and Zilibotti (2006) and Acemoglu and Zilibotti (1999 and 1997), and Aghion and Howitt (2005).

plementary and has a different focus: we study a similar trade-off between investment and selection, but we do so under different and more general conditions. In another related paper, Acemoglu and Zilibotti (1999) study how information may be accumulated along the process of economic development and how this affects risk-sharing, managerial effort and economic performance. Yet, they do not consider alternative contractual forms, while we abstract from risk-sharing. Aghion et al. (2008) relate institutional ownership to a lower risk that managers be replaced in case of bad performance and hence to higher investment in innovation. They also provide empirical evidence supporting the career-concern model: increased institutional ownership is positively correlated with innovation and negatively with the incidence of preformance-driven replacement of managers. Moreover, institutional ownership does not lead to better selection of managers. However, the paper does not study the optimal ownership structure and its evolution with economic development.

The literature on law and economics documents the prevalence of family firms and rigid contractual relationships in developing countries and in particular where enforcement is weak. Theoretical papers explaining this fact argue that family firms arise in the presence of weak institutions (see Mork et al., 2005 for a survey). None of the existing papers, however, study the endogenous evolution of optimal contractual arrangements. We also abstract from enforcement problems and issues related to firm ownership and organization. The corporate finance literature addresses various aspects of the contracts between managers and shareholders. Gabaix and Landier (2008) and Edmans et al. (2009) among others study the equilibrium level of executive compensation and its performance sensitivity in advanced countries. Giannetti (2008) considers the optimal compensation scheme when the outside option of an executive is misaligned with the performance of the firm, depending on labor market conditions. Other contributions (see Benmelech et al., 2007 and references therein) focus on the optimal CEO pay structure, and investigate which instruments better align the interest of managers and shareholders. Our aim is to embed some ideas from this literature in a growth model to study how optimal contracts change with economic development. For this reason, we depart from most of these papers by focusing on simple and incomplete contracts that are more likely to be used also in developing countries.[4]

[4]The literature on optimal manegerial compensation argues that managers should be given a long-term contract specifying state-contingent payments. In the absence of commitment, Clementi

The rest of the paper is organized as follows. Section 2 lays down a simple growth model, describing the set-up and the choices that managers and investors face, and illustrates the main trade-off between selection and investment. Section 3 solves the model under symmetric information, and studies how the optimal contractual arrangement (long- versus short-term contract) varies with the level of development and with other parameters. It shows how, along the development process, countries may start with long-term contracts that maximize investment and endogenously switch to short-term contracts that maximized managerial ability. In section 4, we consider institutional improvements that allow managerial bargaining power to vary with the lifetime of a project, so as to boost investment. We show that the possibility of varying bargaining power is welfare improving and speeds up the transition to short-term contracts. Section 5 introduces an additional informational friction assuming asymmetric information on managerial investment choice. We solve the model and show how asymmetric information may lower welfare by reducing investment, and delay the transition from long- to short-term contractual relationships. Section 6 provides a discussion of our main modelling choices and the empirical implications of our theoretical results. Section 7 concludes.

2 The Model

We propose a simple growth model designed to study the agency problem between investors and managers in a world where managerial ability is not perfectly observable and contracts are incomplete. The model gives rise to a trade-off between selection and investment, with implications for optimal contracts.

2.1 Agents, Preferences and Technology

The economy is populated by a continuum of risk-neutral, infinitely lived, agents who discount the future at the rate $\beta \in (0,1)$. Agents own the capital stock of the economy and can work as managers. The capital stock is a broad measure of the total productive resources of the economy, including both physical and human capital. There is a single final good, produced through "projects" each requiring the combination of capital and one manager. In every period, there is a unit measure of

et al. (2006) show how stock grants may substitute for state-contingent contracts. In the present paper, we assume that contractual inefficiencies prevent the use of complex compensation schemes.

active projects:[5]

$$Y_t = \int_0^1 y_{jt} dj,$$

where y_{jt} is production of project j at time t. Projects run for two periods and, once expired, are replaced by an equal measure of new projects.[6]

When a new project starts at time t, a manager is chosen randomly from the population of agents. At this stage, managerial ability at running the specific project is unknown. The manager receives a given capital stock k_{jt} from investors and decides how to allocate it between current period production and an investment activity that generates new capital at $t+1$. In particular, i_{jt} units of capital invested at t produce $f(i_{jt})$ units of additional capital at $t+1$, were the function $f(\cdot)$ satisfies the regularity conditions: $f'(\cdot) > 0$, $f''(\cdot) < 0$ and $f'(0) = \infty$. Once the investment decision is made, managerial ability, θ_j, is drawn from a normal distribution with mean θ and variance σ_θ^2:

$$\theta_j \sim N\left(\theta, \sigma_\theta^2\right).$$

Ability affects production and is project-manager specific. Hence, it does not change over the lifetime of a project and decays at its end. Production is also affected by a random shock ε_{jt} drawn from a normal distribution with zero mean and variance σ_ε^2:

$$\varepsilon \sim N\left(0, \sigma_\varepsilon^2\right).$$

We assume that the shock ε is independent of ability and uncorrelated across projects and time, so that it captures an unpredictable noise component. Thus, production during the first period of the project is:

$$y_{jt} = (\theta_j + \varepsilon_{jt})(k_{jt} - i_{jt}),$$

Production, minus managerial compensation, is distributed as dividends to investors and consumed. Upon observing y_{jt}, i.e. a noisy signal of managerial ability, and depending on the type of contract offered to the manager (one-period or two-period employment), investors may decide whether to replace the manager with a new random draw or not.

[5] We take the number of available projects as an exogenous characteristic of technology. We also assume that the measure of agents has a higher order of infinty than the measure of projects.

[6] The fraction of old and new project at any time is immaterial.

At time $t+1$, the capital stock is equal to the initial level plus the return from investment:

$$k_{jt+1} = k_{jt} + f\left(i_{jt}\right).$$

Note that there is no depreciation and no new capital can be allocated in the second period, except for the realized past investment $f\left(i_{jt}\right)$. Moreover, given that the project terminates after the second period, at this stage new investment is not allowed and all capital is allocated to production:

$$y_{jt+1} = \left(\theta_{t+1} + \varepsilon_{jt}\right) k_{jt+1},$$

where θ_{t+1} is the ability of the previous manager (θ_j) or, if replaced, a new random draw from the distribution $N\left(\theta, \sigma_\theta^2\right)$. At the end of the period, the project expires, the manger is dismissed and the capital stock k_{jt+1} is returned to the pool of agents. At $t+2$ new projects arise, capital is reallocated among them, and the cycle starts again. Figure 1 summarizes the timing of events.

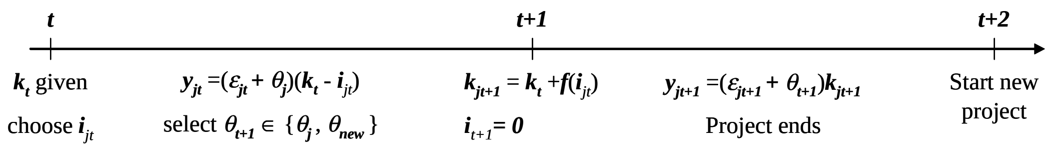

Figure 1: Timing

We now discuss the managerial contract. First, we assume that contracts are incomplete in that they cannot be made contingent on outcomes, such as i_{jt} or y_{jt}. This may be due to the inability of the legal system to verify output and investment. As a consequence, every period the project cash flow is split between managers and investors through ex-post Nash bargaining. For the time being, we assume that managerial bargaining power is exogenous and equal to $\lambda \in (0,1)$. This means that managerial compensation is a fraction λ of the project cash flow, y_{jt}. The fraction λ is public information. As an extension, in section 4 we let the λ vary over the life-time of the project and be chosen optimally. Managers also own a diversified portfolio of shares of all firms, like any other agent in the economy. As all investors, they also receive every period a fraction of the dividends distributed by firms.

Second, the contract may grant investors the option to replace the manager before the termination of the project. In particular, under flexible short-term contracts, the manager is evaluated at the end of the first period and is replaced if the expectation of her ability, conditional on observing the noisy signal y_{jt}, is too low. Alternatively, managers and investors may sign binding long-term contracts that do not allow for this type of managerial turnover. In the remainder of the paper, we study and compare the properties of these alternative contractual arrangements. Before doing so, however, we formally describe the investment choice by mangers and the inference problem that investors face.

2.2 Managers and Investors

The manager chooses investment i_{jt} in order to maximize her expected life-time utility:

$$\max_{i_{jt}} \ \lambda \mathbb{E}\left[y_{jt} + \beta y_{jt+1}\right] + \sum_{\tau=t}^{\infty} \beta^{\tau - t} \mathbb{E}\left(D_{\tau}\right) \tag{1}$$

subject to:

$$\begin{aligned} y_{jt} &= \left(\theta_j + \varepsilon_{jt}\right)\left(k_{jt} - i_{jt}\right) \\ k_{jt+1} &= k_{jt} + f\left(i_{jt}\right) \\ i_{jt} &\leq k_t \end{aligned}$$

where $\mathbb{E}$ is the expectation operator and D_{τ} represents the manager's "dividend" from her portfolio of claims on production of all projects in the economy. Note that the manager takes the stream of dividends as given, for it is proportional to aggregate production and is thus independent of the outcome of any single project j. Therefore, only the first term in (1) is relevant for the investment choice. Substituting the constraints into the objective function and dropping the constant term, we can rewrite the maximization program as:

$$\max_{i_{jt}} \ \theta\left(k_{jt} - i_{jt}\right) + \beta p_{jt}\left(\theta + \delta_{jt}\right)\left[k_{jt} + f\left(i_{jt}\right)\right],$$

where we have used the fact that $\mathbb{E}\left(y_{jt}\right) = \theta\left(k_{jt} - i_{jt}\right)$, p_{jt} is defined as the perceived probability of being confirmed in the second period and $\mathbb{E}\left(\theta_{jt+1} \mid \theta_{jt+1} = \theta_{jt}\right) = \theta + \delta_{jt}$ is the expected ability of a manager that is confirmed. Note that the "selection" effect δ_{jt} is positive if reappointed managers are expected to have an ability higher than the average. Both p_{jt} and δ_{jt} will be determined in equilibrium. As we will see shortly, δ_{jt} will generally depend on the dispersion of managerial talent and the precision of the signal observed by investors. Note that, when making the investment choice, the manager ignores her ability, but knows θ and the expressions for p_{jt} and δ_{jt}.

The first order condition for i_{jt} is:

$$p_{jt}\beta\left(\theta+\delta_{jt}\right)f'\left(i_{jt}\right)=\theta-\beta\left[k_t+f\left(i_{jt}\right)\right]\left[\frac{\partial p_{jt}}{\partial i_{jt}}\left(\theta+\delta\right)+\frac{\partial \delta_{jt}}{\partial i_{jt}}p_{jt}\right]. \tag{2}$$

The left hand side is the expected marginal benefit of investment in terms of higher production at $t+1$. This is equal to the marginal product of investment multiplied by the discount factor and the probability that the manager will be retained. The first term on the right hand side is the cost of investment. The second term on the right hand side is the marginal impact of investment on the probability of being retained and on the selection premium, multiplied by the discounted value of running the firm in the second period. We assume for convenience that the initial capital stock is high enough ($k_0 \geq f'^{-1}\left(\theta/\left(\beta\theta+\beta\delta\right)\right)$) so that $i_{jt} \leq k_t$ at any t.

Investors face an inference problem. They must form expectations on the ability of the manager conditional on observing the noisy signal $y_{jt} = \left(\theta_j+\varepsilon_{jt}\right)\left(k_{jt}-i_{jt}\right)$. Investors know the initial capital stock k_{jt} and may observe (or infer the equilibrium level of) the investment made by the manager, so that they effectively observe the sum $\theta_j+\varepsilon_{jt}$. Given the distributions of θ and ε, that are assumed to be common knowledge, we can calculate the "posterior" expectation on θ_j, conditional on observing $\theta_j+\varepsilon_{jt}$:

$$\widehat{\theta}_{jt}=\mathbb{E}\left[\theta_j \mid \theta_j+\varepsilon_{jt}\right]=\frac{\sigma_\varepsilon^2}{\sigma_\theta^2+\sigma_\varepsilon^2}\theta+\frac{\sigma_\theta^2}{\sigma_\theta^2+\sigma_\varepsilon^2}\left(\theta_j+\varepsilon_{jt}\right). \tag{3}$$

That is, the posterior expectation on managerial ability is a weighted average of the "prior", θ, and the observed signal, $\theta_j+\varepsilon_{jt}$, with weights that depend on the precision of the signal: as the variance of the noise increases relative to the variance of ability, the signal becomes less and less informative and the posterior expectation converges to the unconditional mean. Note also that the distribution of the posterior belief on the manager's ability is normal:

$$\widehat{\theta}_{jt}\sim N\left(\theta,\frac{\sigma_\theta^4}{\sigma_\theta^2+\sigma_\varepsilon^2}\right). \tag{4}$$

Intuitively, $\widehat{\theta}_{jt}$ has the same mean but a smaller variance than θ.

Finally, investors want to maximize the expected present discounted value of their share in the project, $V(k_{jt})$, given the available contracts. This is given by the present value of expected production, net of the managerial compensation, $(1-\lambda)\mathbb{E}[y_{jt}+\beta y_{jt+1}]$:

$$\frac{V(k_{jt})}{1-\lambda} = \theta(k_{jt}-i_{jt}) + \beta(\theta + p_{jt}\delta)[k_{jt}+f(i_{jt})]. \tag{5}$$

We focus on symmetric equilibria where all new projects have the same amount of capital $k_{jt}=k_t$ and all managers make the same investment $i_{jt}=i_t$.[7]

3 Symmetric Information

We now characterize the equilibrium outcome under alternative contractual arrangements assuming that investment is observable to all agents. We relax this assumption in section 5.

3.1 Long-Term Contracts

Suppose that a two-period contract is signed, hence investors are not allowed to replace the manager at the end of the first period. In this case, we have $p_{jt}=1$ and $\partial p_{jt}/\partial i_{jt}=0$ so that the first order condition for investment (2) becomes:

$$\beta f'\left(i^L\right) = 1, \tag{6}$$

where the superscript L denotes long-term contracts. Under long-term contracts, there is no selection so that the ex-ante expected managerial ability in the second period is just the unconditional mean θ and $\delta^L=0$.

3.2 Short-Term Contracts

We now consider the case in which investors sign one-period contracts and are thus free to replace the manager. The optimal strategy for the investors is to fire the manager

[7] This assumption can be justified introducing a diversification motive (as in Acemoglu and Zilibotti, 1997, where allocating capital uniformly across the full range of projects allows to diversify aggregate risk) or if projects produce differentiated goods. We do not allow for competition for projects between managers. Adding an initial stage where potential managers offer lump sum payments to win the competition for project does not modify the results.

if her expected ability, conditional on observing y_{jt} and i_{jt} is below the population average. Thus, the confirmation probability facing a manager is the probability that the posterior belief $\widehat{\theta}_{jt}$ is greater than θ, or equivalently, the probability that the signal is above its mean:

$$p_{jt} = \Pr\left(\widehat{\theta}_{jt} \geq \theta\right) = \frac{1}{2}.$$

Since information is symmetric and i_{jt} observable, managers cannot manipulate the signal by reducing investment. It follows that $\partial p_{jt}/\partial i_{jt} = 0$ and $\partial \delta_{jt}/\partial i_{jt} = 0$. In equilibrium, the first order condition (2) for $i_{jt} = i_t^S$ becomes:

$$\beta f'\left(i^S\right) = \frac{2\theta}{\theta + \delta}. \tag{7}$$

We are now in the position to solve for δ, i.e., the difference between the expected ability of a confirmed manager and a new draw. Confirmed managers tend to be of above average ability ($\delta > 0$) because a realization of y_{jt} above the mean is more likely to come from a high ability manager, although there is always a chance that it comes from low-θ type with a very lucky realization of the shock ε_{jt}. Formally, given that a manager is retained whenever her ability is expected to be above θ, the average ability of a confirmed manager is equal to the mean of the distribution of the posterior belief $\widehat{\theta}_{jt}$ truncated below at θ :

$$\mathbb{E}\left[\theta_j \mid \widehat{\theta}_{jt} \geq \theta\right] = \frac{1}{1 - H(\theta)} \int_{\theta}^{\infty} \widehat{\theta} dH\left(\widehat{\theta}\right) = \theta + \frac{2\sigma_\theta^2}{\sqrt{2\pi\left(\sigma_\theta^2 + \sigma_\varepsilon^2\right)}},$$

where H is the c.d.f. of the posterior belief $\widehat{\theta}_{jt}$ (4).

Thus, the "selection effect", i.e., the expected ability premium of a confirmed manager, is:

$$\delta = \frac{2\sigma_\theta^2}{\sqrt{2\pi\left(\sigma_\theta^2 + \sigma_\varepsilon^2\right)}}. \tag{8}$$

Note that selection is more effective (high δ) when the signal is not too noisy (low σ_ε^2) and ability very dispersed (high σ_θ^2). Intuitively, when there is little noise, the probability of keeping by mistake a bad manager is low, thereby raising the benefit of selection. On the contrary, when talent is very concentrated, there is little to gain in confirming a manager, even when she is expected to be of above average ability. High heterogeneity in ability makes instead selection a powerful tool. In sum, the effect of uncertainty on selection and managerial ability depends crucially on whether uncertainty is due to the dispersion of managerial talent or to idiosyncratic noise.

On the other hand, selection may come at a cost. To see this, note that conditions (7) and (6) imply $i^S < i^L$ as long as the selection effect does not outweighs average ability ($\delta < \theta$). In this case, investment under short-term contracts is lower than under long-term contracts. When $\delta > \theta$, instead, short-term contracts entail higher investment because the ability of a confirmed manager (hence productivity) is expected to be so high that the manager prefers to boost second period production (through higher investment) even if she only has a 50% chance to enjoy the returns. In this case, short-term contracts do not impose a trade-off between investment and selection. For this reason, we focus on the more interesting case $\delta < \theta$.

3.2.1 Incentives and Investment

We now study the determinants of investment, i^S. Since $f''\left(i^S\right) < 0$, the left hand side of (7) is decreasing in i^S. It is then easy to characterize investment as a function of the model parameters.

Lemma 1 *Investment under short-term contracts is an increasing function of heterogeneity in managerial ability (σ_θ^2), and patience (β); it is decreasing in average ability (θ), and noise (σ_ε^2).*

$$\frac{\partial i^S}{\partial \sigma_\theta^2} > 0; \quad \frac{\partial i^S}{\partial \beta} > 0; \quad \frac{\partial i^S}{\partial \theta} < 0; \quad \frac{\partial i^S}{\partial \sigma_\varepsilon^2} < 0$$

Proof. *See Appendix* ■

Not surprisingly, investment increases with patience, β. Heterogeneity in ability, σ_θ^2, increases investment since it raises the manager's expected ability conditional on being confirmed in the second period (δ) and thus the marginal return from i^S. For given σ_θ^2, higher average ability raises the marginal cost of investment (θ) more than its expected marginal return (proportional to $\theta + \delta$), thereby reducing the incentives to invest. An increase in the variance of the shocks, σ_ε^2, makes confirmation of a manager less revealing of higher expected ability (δ falls), thereby inducing to invest less.

3.3 The First Best

Before comparing the relative performance of short- and long-term contract, it is useful to characterize the first-best solution that would be attained if investment were verifiable and thus contractible. In this case, investment i_t^{FB} would be chosen so as to maximize the expected present discounted value of the project. Moreover, to maximize second-period productivity, investors would keep the right to replace managers if they produce less than the expected average $\theta\left(k_t - i_t^{FB}\right)$. This happens with probability one-half since ability is symmetrically distributed around its mean and shocks are i.i.d.. Thus, the first best investment solves:

$$\max_{i_{jt}} \; \theta\left(k_t - i_{jt}\right) + \beta\left(\theta + \frac{\delta}{2}\right)\left[k_t + f\left(i_{jt}\right)\right].$$

The f.o.c. is:

$$\beta f'\left(i^{FB}\right) = \frac{2\theta}{2\theta + \delta}. \tag{9}$$

From conditions (6), (7) and (9) it is immediate to see that $i^L < i^{FB}$ and $i^S < i^{FB}$. Thus, contact incompleteness always implies under-investment. The reason is that long-term contracts exclude the beneficial effect of selection on investment. Short-term contracts, instead, introduce myopia in managerial behavior. Moreover, when $\delta < \theta$, we have $i^S < i^L < i^{FB}$.

3.4 Appropriate Contracts and Economic Development

We now compare the welfare properties of short- and long-term contracts and study how the optimal contractual form changes along the process of economic development. As long as $\delta < \theta$, long-term contracts maximize investment, but sacrifice managerial selection; on the other hand, short-term contracts allow on average to replace bad managers, at the cost of underinvestment. Thus, the choice between alternative contracts poses a trade-off between investment and selection. To study it, we evaluate the expected present discounted value of new projects (5) in the two cases:

$$\text{Long-term:} \quad \frac{V^L\left(k_t\right)}{1-\lambda} = \theta\left(k_t - i^L\right) + \beta\theta\left[k_t + f\left(i^L\right)\right],$$

$$\text{Short-term:} \quad \frac{V^S\left(k_t\right)}{1-\lambda} = \theta\left(k_t - i^S\right) + \beta\left(\theta + \frac{\delta}{2}\right)\left[k_t + f\left(i^S\right)\right]$$

where δ is given by (8). Rearranging these expressions, we find that short-term, flexible, contracts are ex-ante optimal, i. e. $V^S(k_t) > V^L(k_t)$, when the following condition holds:

$$\frac{\beta\left[k_t + f\left(i^S\right)\right]}{\left[\beta f\left(i^L\right) - i^L\right] - \left[\beta f\left(i^S\right) - i^S\right]} > \frac{2\theta}{\delta}. \tag{10}$$

This condition is always satisfied when the selection effect is at least equal to average ability ($\delta \geq \theta$). For lower values of δ, (10) holds when selection is relatively more important than investment. In fact, it holds trivially when $f(i_t) = 0$, while it is always violated when the benefit of selection is nil ($\delta = 0$).

We next ask how capital accumulation affects the optimal choice of contract. As formalized in Proposition 1, capital accumulation makes short-term contracts more attractive.

Proposition 1 *There exists k^* such that $V^S(k) \geq V^L(k)$ for any $k > k^*$.* ***Proof.*** *See Appendix* ■

Intuitively, ability becomes relatively more important as k_t grows because of its complementarity to capital. For this reason, the higher the capital stock the higher the value of selection. Key to this property is the assumption that managerial talent has a multiplicative effect, as in the majority of models designed to study the impact of managerial quality.[8]

Since investment is non-negative and there is no depreciation, capital grows over time. In particular, each project starting at time $t+1$ is allocated capital

$$k_{t+1} = k_t + f(i_t).$$

This implies that, for any parameter value, the economy reaches k^* in finite time. Thus, Corollary 1 immediately follows.

Corollary 1 *For any parameter value, there exist a time t^* such that $V^S(k_t) \geq V^L(k_t)$ for all $t \geq t^*$.*

Our model thus predicts that countries starting from a low level of capital may go through an initial phase where long-term production relationships and low managerial turnover are optimal. Once k_t reaches a critical threshold, however, ability

[8] See for example Rosen (1981) and Gabaix and Landier (2008) and the large literature on capital-skill complementarity (e.g., Krusell et al. 2000). Span of control models suggest the effect of ability to decline as project size grows, however.

becomes more important and the economy will endogenously switch to flexible short-term contracts. Appropriate contractual institutions may thus evolve with economic development as suggested by Kuznets (1966, 1973), Gerschenkron (1962) and North (1994).

We now discuss the effects of other parameters on the choice of appropriate contracts, and hence the speed of transition, in the non-trivial case $\delta < \theta$.

Proposition 2 *The expected difference in the PDV of a project under short-term relative to long-term contracts,* $\Delta V \equiv \frac{V^S(k_t)}{1-\lambda} - \frac{V^L(k_t)}{1-\lambda}$*, is: (1) decreasing in average ability; (2) decreasing in the variance of the shock (σ_ε^2); and (3) increasing in the variance of the ability distribution (σ_θ^2).*

$$\frac{\partial \Delta V}{\partial \theta} \leq 0; \quad \frac{\partial \Delta V}{\partial \sigma_\varepsilon^2} \leq 0; \quad \frac{\partial \Delta V}{\partial \sigma_\theta^2} \geq 0.$$

Proof. *See Appendix* ■

The intuition behind the first result in Proposition 2 is that, for a given variance σ_θ^2, a high θ makes selection relatively less important. To see this, note that the benefit of selection, δ, is independent of ability, while its cost, in terms of lower k_{t+1}, increases with θ. Moreover, a high θ tends to reduce investment i^S, thereby lowering $V^S(k_t)$ even further. Thus, the relative value of short-term contracts falls with θ. Note however that this result may be overturned if σ_θ^2 increases with θ.

The effect of σ_ε^2 (noise) is to make it more difficult to separate good and bad managers, thereby reducing the benefit of selection δ and the managerial incentive to invest under one-period contracts. It is easy to show that, if the noise is high enough ($\sigma_\varepsilon^2 \to \infty$), selection is void ($\delta \to 0$), hence long-term contracts are optimal, regardless of the level of development. As noise tends to zero, the selection effect becomes maximum, though bounded ($\delta \to \sqrt{2\sigma_\theta^2/\pi}$), thereby making (10) more likely to hold. Hence, improvements in the availability of information that lower the noise (e.g., more transparency in business procedures or a better monitoring technology) speed up the transition to flexible contractual institutions.

A rise in the variance of managerial talent instead makes short-term contacts relatively more efficient because a high σ_θ^2 increases the selection premium δ in (8), which raises $V^S(k_t)$ both directly and indirectly through the rise in i^S. Moreover, it is easy to show that, if there is no heterogeneity in talent, the selection effect (δ) is nil, hence rigid contracts are always preferable. If ability is dispersed enough ($\sigma_\theta^2 \to \infty$) instead, the selection effect grows very large ($\delta \to \infty$) thereby making short-term contracts optimal.

Corollary 2 *For any parameter value, there exists $\widehat{\sigma}_\theta^2 > 0$ such that short-term contracts are optimal for all $\sigma_\theta^2 \geq \widehat{\sigma}_\theta^2$.* ***Proof.*** *See Appendix* ■

In sum, more homogeneous societies (i.e., with a low σ_θ) will stay longer in the development phase characterized by long-term contracts. This may help explain why relatively rigid production relationships may be common even in some advanced country (Japan, for example) and in some traditional sectors where ability matters less.

4 Varying Bargaining Power

Although contract incompleteness precludes contingent contracts, a recent literature (e.g. Hart, 1995 and references therein) has argued that actions affecting the allocation of bargaining power between parties may improve incentives. In this spirit, we now consider a richer institutional framework that lets the bargaining power of managers and investors be allocated differently across the first and second period. In particular, we assume that λ still defines the minimum bargaining share of managers. For instance, this may be the fraction of cash flow that the manager can hide and appropriate without being prosecuted. However, investors may have the option to raise the managerial bargaining power associated to each stage of a project: $\lambda_1 \in [\lambda, \lambda^{\max}]$ and $\lambda_2 \in [\lambda, \lambda^{\max}]$, where $1 - \lambda^{\max} > 0$ is the minimum share that investors must receive. We now study how this institutional improvement affects the efficiency of contracts and the transition studied above.

The manager's problem becomes:

$$\max_{i_t} \ \lambda_1 \theta \left(k_t - i_t\right) + \beta \frac{1}{2} \lambda_2 \left(\theta + \delta\right) \left[k_t + f\left(i_t\right)\right],$$

with the equilibrium first order condition

$$\beta f'\left(i^\lambda\right) = \frac{\lambda_1}{\lambda_2} \frac{2\theta}{\theta + \delta}. \tag{11}$$

It is easy to see that investment is increasing (decreasing) in the second (first) period compensation, λ_2 (λ_1) and the comparative statics for the other parameters remains the same as in the previous section.

If investors were able to choose λ_1 and λ_2, they could have an incentive to give up cash flow (by raising λ_2) in order to foster investment. In particular, they would set managerial bargaining power so as to maximize the expected present discounted value of their own share in the project:

$$\max_{\lambda_1,\lambda_2} (1-\lambda_1)\,\theta\left(k_t - i^{\lambda}\right) + \beta\left[k_t + f\left(i^{\lambda}\right)\right](1-\lambda_2)\left(\theta + \frac{\delta}{2}\right) \tag{12}$$

subject to (11) and $\lambda_1 \in [\lambda, \lambda^{\max}]$, $\lambda_2 \in [\lambda, \lambda^{\max}]$.

Given that raising λ_1 reduces both current investors' share of cash flow and investment, it will always be set to its minimum λ, as shown in the Appendix. The f.o.c. for an interior λ_2 is:

$$\beta\left(\theta + \frac{\delta}{2}\right)\left[k_t + f\left(i^{\lambda}\right)\right] = \left[\beta f'\left(i^{\lambda}\right)(1-\lambda_2)\left(\theta + \frac{\delta}{2}\right) - (1-\lambda)\,\theta\right]\frac{\partial i^{\lambda}}{\partial \lambda_2}. \tag{13}$$

The LHS of (13) represents the marginal cost of increasing second-period managerial bargaining power, which is proportional to second-period cash flow. The RHS captures the net marginal benefit of higher λ_2 through the rise in investment it generates. If, for any $\lambda_2 \in [\lambda, \lambda^{\max}]$, the LHS is greater (smaller) than the RHS, the solution is $\lambda_2 = \lambda$ ($\lambda_2 = \lambda^{\max}$).

Under long-term contracts ($\delta = 0$), investment is determined by the equation $\beta f'\left(i^{\lambda L}\right) = \lambda/\lambda_2$, hence the first order condition (13) becomes:

$$\beta\left[k_t + f\left(i^{\lambda L}\right)\right] = \left(\frac{\lambda}{\lambda_2} - 1\right)\frac{\partial i^{\lambda L}}{\partial \lambda_2}.$$

Given that the LHS is positive, while the RHS is negative for any $\lambda_2 > \lambda$, the optimal solution is always at the corner, $\lambda_2 = \lambda$, and the equilibrium is the same as in section 3, with $\beta f'\left(i^{\lambda L}\right) = \beta f'\left(i^{L}\right) = 1$ and $V^{\lambda L}(k_t) = V^{L}(k_t)$. Intuitively, in this case there is no reason to change managerial incentives because, conditional on no selection, long-term contracts already yield the optimal level of investment, .

Under short-term contracts, the optimal λ_2 is interior if condition (13) holds with equality. In this case, investors' welfare is higher than under the simple short-term contracts of section 3 ($V^{\lambda S}(k_t) > V^{S}(k_t)$), since investment is higher: $\beta f'\left(i^{\lambda S}\right) = \beta f'\left(i^{S}\right)\lambda/\lambda_2$. Second period managerial power is optimally set at its lower bound, $\lambda_2 = \lambda$, if its marginal cost is higher than its marginal benefit, i.e., if after replacing

$\lambda_2 = \lambda$ into (11), (13) holds with inequality:

$$\left[k_t + f\left(i^S\right)\right] \frac{\lambda}{1-\lambda} > \frac{\theta}{2\theta+\delta} \left(\frac{2\theta}{\theta+\delta}\right)^2 \left(-\frac{1}{f''\left(i^S\right)}\right).$$

This means that the solution with variable managerial bargaining power tends to the simple short-term contract (with $\lambda_2 = \lambda_1 = \lambda$), as capital ($k_t$) grows, ability gets more dispersed ($\sigma_\theta^2 \uparrow$) and noise and average ability fall ($\sigma_\varepsilon^2 \downarrow \theta \downarrow$), i.e., when investment becomes relatively less important than selection. Moreover, variable bargaining power is less useful when managers already have high control over the firm's cash flow (λ).

This result is consistent with the notion that ex-ante efficiency requires that a higher bargaining power should be allocated to the party that makes the most important task (e.g., Hart, 1995). In our model, we can think of investment as a task performed by managers and selection as a task performed by investors. When investment is more important than selection, namely when capital stock is small, ability is homogeneous (high θ/σ_θ^2) and noise is large, the manager should be given relatively more bargaining power, while the opposite happens when selection is more relevant.

In sum, we have shown that the choice of λ_1 and λ_2 does not affect long-term contracts, while it (weakly) improves short-term contracts ($V^{\lambda S} \geq V^S$). Moreover, the trade-off between investment and selection under alternative contracts is typically preserved and the economy converges necessarily to the benchmark case $\lambda_1 = \lambda_2 = \lambda$ as k grows. The new important result is that short-term contracts will become preferable to long-term contracts for a smaller level of capital than in section 3 and hence the transition will be faster. Note however that, when managerial power is time-varying, social welfare is no longer aligned with that of investors and managers, and hence the level of investment achieved with the λs chosen by investors need not coincide with the first best allocation.

5 Asymmetric Information

We finally assume that investment is unobservable to the investors. This allows us to study the trade-off between short- and long-term contracts in an environment with more informational frictions. It is immediate to show that this form of informational asymmetry has no bearings on long-term contracts. Under short-term contracts, instead, asymmetric information introduces an additional distortion in the choice of investment due to a career-concern motive. In particular, managers will invest less in an attempt to manipulate the signal of their ability and hence their confirmation probability. In equilibrium, however, investors will correctly foresee the behavior of managers and p will still be one-half.

Unobservability implies that investors will rely upon equilibrium investment i_t^U, instead of the observed one, when extracting the ability signal from the firm's performance y_{jt}. Thus, a manager will be retained if the project cash flow, y_{jt}, is higher than that obtained by the average manager doing the equilibrium investment:

$$(\theta_j + \varepsilon_{jt})(k_t - i_{jt}) \geq \theta \left(k_t - i_t^U\right).$$

The manager's perceived probability of being confirmed becomes

$$p_{jt} = \Pr\left[\theta_j + \varepsilon_{jt} \geq \theta \frac{k_t - i_t^U}{k_t - i_{jt}}\right] = 1 - G\left(\theta \frac{k_t - i_t^U}{k_t - i_{jt}}\right),$$

where G is the c.d.f. of $\theta_j + \varepsilon_{jt} \sim N\left(\theta,\ \sigma_\theta^2 + \sigma_\varepsilon^2\right)$. By distorting the signal extraction problem of investors, off-equilibrium investment affects this probability and the manager's expected ability conditional on being retained:

$$\mathbb{E}\left[\theta_j \mid \theta_j + \varepsilon_{jt} \geq \theta \frac{k_t - i_t^U}{k_t - i_{jt}}\right] = \frac{1}{1 - H\left(\widetilde{\theta}\right)} \int_{\widetilde{\theta}}^{\infty} \widehat{\theta} dH\left(\widehat{\theta}\right) = \theta + \delta_{jt}$$

with

$$\widetilde{\theta} = \theta + \frac{\sigma_\theta^2}{\sigma_\theta^2 + \sigma_\varepsilon^2} \frac{i_{jt} - i_t^U}{k_t - i_{jt}}.$$

In equilibrium, rational expectations imply $i_t^U = i_{jt}$, so that we obtain $p_{jt} = p = \frac{1}{2}$, $\delta_{jt} = \delta$,

$$\frac{\partial p_{jt}}{\partial i_{jt}} = -\frac{\theta g(\theta)}{k_t - i_t^U},$$

and

$$\frac{\partial \delta_{jt}}{\partial i_{jt}} = \frac{g(\theta)}{k_t - i_t^U} 2\delta$$

with $g(\theta) = [2\pi(\sigma_\theta^2 + \sigma_\varepsilon^2)]^{-1/2}$. The first order condition for i_t^U becomes:

$$\beta f'\left(i_t^U\right) = \frac{2\theta}{\theta + \delta} + \beta \frac{k_t + f\left(i_t^U\right)}{k_t - i_t^U} \frac{2g(\theta)}{\theta + \delta} \left[\theta(\theta + \delta) - \delta\right] \tag{14}$$

Comparing (14) with the first order condition in (7) gives a measure of the distortion brought by unobservability of investment. In this case, selection is more costly in terms of foregone investment since, with $\partial p_{jt}/\partial i_{jt} < 0$, managers are willing to give up some investment in favor of current production in an effort to manipulate the perception of their ability and increase the probability of being retained. In equilibrium, given that the level of investment is rationally foreseen by investors, we still have $p = 1/2$. That is, the probability of being retained is just the exogenous probability of having a higher than average ability. Yet, the unsuccessful attempt to manipulate the signal of ability introduces a short-run bias in investment. On the other hand, a higher (off-equilibrium) investment increases the expected ability conditional on being confirmed and induces more investment due to the capital-ability complementarity. This second effect is always dominated under the natural assumption $\theta > 1$, so that managers invest less under asymmetric information: $i_t^U \leq i^S$.

As in section 3.3, short-term contracts are more efficient if and only if condition (10) is satisfied after replacing i^S with i_t^U:

$$\frac{\left[k_t + f\left(i_t^U\right)\right]}{\left[\beta f\left(i^L\right) - i^L\right] - \left[\beta f\left(i_t^U\right) - i_t^U\right]} > \frac{2\theta}{\beta\delta}$$

Also here, we will focus on the non-trivial case in which long-term contracts yield higher investment than short-term contracts: $i_t^U < i^L$.

It is can be shown that the results in Proposition 1 and Corollary 1, stating that as capital is accumulated societies switch to short-term contracts, still holds. Moreover, since investment under short-term contracts is lower when i_{jt} is unobservable while δ is the same, we have $V^U < V^S$ for any parameter value and capital is accumulated at a lower rate. This implies that asymmetric information unambiguously slows down the transition to short-term contracts (k^* and t^* are higher).

6 Discussion

Before concluding, we pause to briefly discuss some of the key assumptions maintained in our model and to draw some empirical implications of our theoretical results.

6.1 Modelling choices

In line with the incomplete contract literature, we have excluded contracts contingent on production (due to a lack of verifiability), but we have abstracted from commitment issues too. That is, we have assumed that legal enforcement is imperfect but sophisticated enough to make the choice of one or two period contracts binding. For the purpose of the paper, namely, to study the observed persistence of long-term production relationships in less developed countries, our approach seems a natural compromise. In fact, in the absence of any commitment technology, rigid contracts would be much harder to implement. The reason is a time consistency problem. Even if investor would like to promise reappointment ex-ante, in order to induce the optimal investment, they may want to deviate ex-post. Once investment is realized and y_{jt} observed, investors will form expectation on the ability of the current manager. If this ability happens to be below the average, investors are better off in expectation by replacing the manager with a new draw. Thus, for long-term contracts to arise, there must be institutions that can enforce the original promise not to fire the manager. To circumvent the problem, if private contracts are difficult to enforce, the government may provide commitment by choosing labor market institutions that impose long-term relationship. Examples of this might be policies of tenured or lifetime employment. Alternatively, if there is no enforcement mechanism to sustain long-term contracts, it is possible that family firms, where the manger is also the owner of the firm, could provide a solution to the commitment problem. Provided that managerial compensation is large enough, the owner of a family firm will keep its control unless his managerial talent is very low. Thus, family firms may arise when long-term contracts are optimal, but not enforceable.[9]

Second, in the interest of simplicity, we have restricted the investors' choice (and their ability to commit) to short- versus long-term contracts only. In a richer environment, investors may be willing to sign two-period contracts that specify a severance pay in case the manager is replaced. The effect would be to increase the confirmation probability p_{jt} above one-half and thus the incentive to invest, at the cost of less selection. Our model captures the essence of this trade-off without the additional complications that this form of "limited commitment" would pose. Moreover, the

[9] More generally, our model suggests that lack of commitment may be more costly in less developed countries where long-term contracts would be optimal.

severance pay may be subject to severe disputes.

Finally, we have assumed that managers choose investment without knowing their own ability to avoid the multiplicity of equilibria typical of signaling games. Besides signaling, our model suggests that a possibly more interesting reason for multiple equilibria and development traps may arise by endogenizing the ability distribution. In our set-up, under long-term contracts ability is less important so that managers may have a lower incentive to invest in activities, such as education, that could increase talent. At the same time, this may lead to a more compressed ability distribution that in turn justifies the adoption of long-term contracts. This may help explain why some countries appear to be trapped in a no-selection, low-human capital equilibrium.

6.2 Empirical implications

The main theoretical results in the previous sections suggest that short-term production relationships, whereby bad performance leads to manager replacement, are more likely to prevail at higher stages of development (high capital stock), where transparency in corporate governance is higher (low σ_ε^2, and/or absence of asymmetric info), and managerial ability is more dispersed (high σ_θ^2). A number of empirical implication can be drawn to confront our model with the real world.

Cross-country data would lend support to the model predictions if: (1) higher economic development raised the likelyhood that bad firm performance leads to CEO termination; (2) controlling for development, better corporate law and practice (e.g., disclosure requirements, informativeness of stock prices) raised the likelyhood that bad performance leads to CEO termination. Several contributions in corporate finance study the determinants of managerial turnover. Among these, De Fond and Hung (2004) show that CEO termination is more performance sensitive in countries with better corporate governance (laws and their enforcement), and where stock market prices are more informative, which we can interpret as lower σ_ε^2 in light of our model. Lel and Miller (2008) provide evidence that firms from developing countries (or countries with bad corporate governance) that are cross listed in the New York Stock Exchange, characterized by severe disclosure requirements (hence low σ_ε^2), display increased performance sensitivity of CEO termination. The same is not true for firms that cross-list in the London Stock Exchange, that has less severe requirements. This suggests that firms switch to more short-term contracts as soon as they become subject to better governance rules that make selection more effective.

In the model, capital is uniformely allocated to all projects, so there is no variation in firm size, and the same contractual arrangement applies to the whole economy. We can however obtain our results in a partial equilibrium setting, where firms (or sectors) differ in size. In this case, the empirical implications would be that short-term contracts prevail: (1) in larger firms, (2) where managerial ability is more dispersed, or production is more complex so that managerial ability matters more (high σ_θ^2); and (3) idiosyncratic risk is lower, or investors have better control (low σ_ε^2). To our knowledge, there are no studies relating the performance sensitivity of managerial turnover to size, volatility and complexity at the firm level. The most related evidence is provided by Zhou (2000) showing that large Canadian firms are more likely to terminate their CEO after bad performance than small firms are.

7 Conclusions

In this paper, we have built a simple growth model where economic success requires both incentive to undertake investments that pay out in the future and managerial selection. Investment is relatively more important at early stages of development, when the capital stock is low. It is then optimal to choose long-term contracts that maximize the incentive to invest, even at the cost of no managerial selection. As the capital stock grows, ability becomes more important and the economy endogenously switches to short-term contracts that maximize managerial talent, even at the cost of some underinvestment. We have also studied how other parameters affect the speed of the transition. Another result of our analysis is that countries with better institutions and less informational frictions will experience a faster transition to short-term contracts.

Our model can be used to analyze the effects of policies that improve the availability of information. For example, financial development may bring about a better monitoring technology that lowers the amount of noise in the economy. Likewise, financial openness may allow investors to hold claims on foreign firms and this may provide access to privileged information, such as balance sheets and investment reports. By comparing economic performance of firms in the same sector in different countries, investors may acquire information on global sectorial shocks and reduce the noise in the ability signals they observe from managers. Thus, by reducing uncertainty, financial development and financial openness may speed up the transition to flexible contracts, improve selection and increase managerial ability. These results can help rationalize the findings in Beck, Levine and Loayza (2000) and Bonfiglioli (2008) that financial development and liberalization spur productivity, particularly in developed countries, but not investment.

The results in this paper have been obtained with the help of a highly stylized model. To preserve transparency and to isolate the agency problem between investors and managers, we have adopted a minimalist approach that abstracts from many interesting issues. Given that the resulting model has proven to be tractable, we hope it can serve as a building block for future extensions. For instance, although we have emphasized the implications of the model for cross-country comparison, its logic may shed light on cross-industry comparisons as well. It could then help explain why rigid contractual relationships tend to prevail in more traditional sectors where skills matter less. Finally, as suggested in the previous section, endogenizing the ability distribution seems a particularly interesting avenue for future research.

8 Appendix

8.1 Proof of Lemma 1

Re-write the first order condition for optimal investment under short-term contracts, eq. (7), as

$$I \equiv \beta \frac{f'\left(i^S\right)}{2} - \frac{\theta}{\theta + \delta} = 0.$$

This equation defines investment as an implicit function of the other variables and parameters of the model. To prove Lemma 1, we compute the derivatives of investment with respect to patience (β), ability dispersion (σ_θ^2), noise (σ_ε^2) and average ability (θ):

$$\frac{\partial i^S}{\partial x} = -\frac{\partial I}{\partial x} \Big/ \frac{\partial I}{\partial i_t^S}$$

where

$$\frac{\partial I}{\partial i^S} = \frac{1}{2} \beta f''\left(i^S\right) < 0.$$

Lemma 1 follows from:

$$\frac{\partial I}{\partial \beta} = \frac{1}{\beta^2} > 0,$$

$$\frac{\partial I}{\partial \sigma_\theta^2} = \frac{\theta}{(\theta+\delta)^2} \frac{\partial \delta}{\partial \sigma_\theta^2} = \frac{\theta}{(\theta+\delta)^2} \frac{\sigma_\theta^2 + 2\sigma_\varepsilon^2}{2\sigma_\theta^2 \left(\sigma_\theta^2 + \sigma_\varepsilon^2\right)} \delta \geq 0,$$

$$\frac{\partial I}{\partial \sigma_{\varepsilon}^{2}} = \frac{\theta}{(\theta+\delta)^{2}} \frac{\partial \delta}{\partial \sigma_{\varepsilon}^{2}} = -\frac{\sigma_{\theta}^{2}}{(\sigma_{\theta}^{2}+\sigma_{\varepsilon}^{2})^{\frac{3}{2}}\, 2\sqrt{\pi}} \leq 0,$$

$$\frac{\partial I}{\partial \theta} = -\frac{\delta}{(\theta+\delta)^{2}} < 0.$$

8.2 Proof of Proposition 1

To prove Proposition 1, we only need to show that the difference between the PDV of the project under short-term and long-term contracts, $\Delta V \equiv \frac{V^{S}(k_t)}{1-\lambda} - \frac{V^{L}(k_t)}{1-\lambda}$, is increasing in the stock of capital, k_t. The derivative of ΔV w.r.t. k_t is

$$\frac{\partial \Delta V}{\partial k_t} = \beta \frac{\delta}{2} > 0.$$

8.3 Proof of Proposition 2

To prove Proposition 2, we show that, for $\delta < \theta$,

$$\Delta V = \theta \left[\beta f\left(i^{S}\right) - i^{S}\right] - \theta \left[\beta f\left(i^{L}\right) - i^{L}\right] + \beta \frac{\delta}{2} \left[k_t + f\left(i^{S}\right)\right]$$

is decreasing in θ, increasing in σ_{θ}^{2}.and decreasing in σ_{ε}^{2}.

$$\frac{\partial \Delta V}{\partial \theta} = \left[\beta f\left(i^{S}\right) - i^{S}\right] - \left[\beta f\left(i^{L}\right) - i^{L}\right] + \frac{\partial i^{S}}{\partial \theta} \left[\beta \left(\theta + \frac{\delta}{2}\right) f'\left(i^{S}\right) - \theta\right]$$

is negative, because: (1) $\left[\beta f\left(i^{S}\right) - i^{S}\right] < \left[\beta f\left(i^{L}\right) - i^{L}\right]$ since $\beta f(i) - i$ is increasing in investment and $i^{S} < i^{L}$, (2) $\partial i^{S}/\partial \theta < 0$ from Lemma 1, and (3) $\beta\left(\theta + \frac{\delta}{2}\right) f'\left(i^{S}\right) = \left(2\theta + \delta\right) / \left(\theta + \delta\right) \theta > \theta$.

$$\frac{\partial \Delta V}{\partial \sigma_{\theta}^{2}} = \frac{\partial i^{S}}{\partial \sigma_{\theta}^{2}} \left[\beta \left(\theta + \frac{\delta}{2}\right) f'\left(i^{S}\right) - \theta\right] + \frac{\partial \Delta V}{\partial \delta} \frac{\partial \delta}{\partial \sigma_{\theta}^{2}},$$

is positive, because: (1) $\partial i^{S}/\partial \sigma_{\theta}^{2} > 0$ from Lemma 1, (2) $\partial \Delta V/\partial \delta = \beta\left[k_t + f\left(i^{S}\right)\right]/2 > 0$, and (3)

$$\frac{\partial \delta}{\partial \sigma_{\theta}^{2}} = \frac{1}{2\sqrt{\left(\sigma_{\theta}^{2} + \sigma_{u}^{2}\right)\pi}} \left[1 - \frac{\sigma_{\theta}^{2}}{\left(\sigma_{\theta}^{2} + \sigma_{\varepsilon}^{2}\right)}\right] \geq 0.$$

$$\frac{\partial \Delta V}{\partial \sigma_{\varepsilon}^{2}} = \frac{\partial i^{S}}{\partial \sigma_{\varepsilon}^{2}} \left[\beta \left(\theta + \frac{\delta}{2}\right) f'\left(i^{S}\right) - \theta\right] + \frac{\partial \Delta V}{\partial \delta} \frac{\partial \delta}{\partial \sigma_{\varepsilon}^{2}},$$

is negative, because: (1) $\partial i^S/\partial\sigma_\varepsilon^2 > 0$ from Lemma 1, and (2)

$$\frac{\partial\delta}{\partial\sigma_\varepsilon^2} = -\frac{\sigma_\theta^2}{2\left(\sigma_\theta^2+\sigma_\varepsilon^2\right)\sqrt{\pi}} < 0.$$

8.4 Proof of Corollary 1

For σ_θ^2 close to zero the selection effect (δ) tends to zero, hence

$$\lim_{\sigma_\theta^2\to 0}\Delta V = \theta\left[\beta f\left(i^S\right)-i^S\right]-\theta\left[\beta f\left(i^L\right)-i^L\right] < 0,$$

since $i^S < i^L$ and $\beta f(i) - i$ is increasing in i.

Since ΔV is increasing in σ_θ^2, as proved in Proposition 2, a value $\widehat{\sigma}_\theta^2 > 0$ must exist such that $\Delta V > 0$ for all $\sigma_\theta^2 \geq \widehat{\sigma}_\theta^2$.

8.5 Optimal managerial bargaining power

The f.o.c. for λ_1 and λ_2 that solve problem (12)-(**??**) are:

$$\theta\left(k_t - i_t^\lambda\right) \geq \left[\beta f'\left(i_t^\lambda\right)(1-\lambda_2)\left(\theta+\frac{\delta}{2}\right)-(1-\lambda_1)\theta\right]\frac{\partial i}{\partial\lambda_1} \quad (15)$$

$$\beta\left(\theta+\frac{\delta}{2}\right)\left[k_t+f\left(i_t^\lambda\right)\right] \geq \left[\beta f'\left(i_t^\lambda\right)(1-\lambda_2)\left(\theta+\frac{\delta}{2}\right)-(1-\lambda_1)\theta\right]\frac{\partial i}{\partial\lambda_2} \quad (16)$$

for $\lambda \leq \lambda_1$ and $\lambda \leq \lambda_2$, and

$$\theta\left(k_t - i_t^\lambda\right) < \left[\beta f'\left(i_t^\lambda\right)(1-\lambda_2)\left(\theta+\frac{\delta}{2}\right)-(1-\lambda_1)\theta\right]\frac{\partial i}{\partial\lambda_1}$$

$$\beta\left(\theta+\frac{\delta}{2}\right)\left[k_t+f\left(i_t^\lambda\right)\right] < \left[\beta f'\left(i_t^\lambda\right)(1-\lambda_2)\left(\theta+\frac{\delta}{2}\right)-(1-\lambda_1)\theta\right]\frac{\partial i}{\partial\lambda_2}$$

for $\lambda^{\max} = \lambda_1$ and $\lambda^{\max} = \lambda_2$.

Investment is decreasing (increasing) in first (second)-period bargaining power, as shown by

$$\frac{\partial i}{\partial\lambda_1} = \frac{1}{\beta f''\left(i_t^\lambda\right)}\frac{1}{\lambda_2}\frac{2\theta}{\theta+\delta} < 0$$

$$\frac{\partial i}{\partial\lambda_2} = -\frac{1}{\beta f''\left(i_t^\lambda\right)}\frac{\lambda_1}{(\lambda_2)^2}\frac{2\theta}{\theta+\delta} > 0.$$

It follows that necessary condition for an interior solution $\lambda < \lambda_1 < \lambda^{\max}$ is that (15) holds with equality:

$$\beta f'\left(i_t^{\lambda}\right)(1-\lambda_2)\left(\theta+\frac{\delta}{2}\right)-(1-\lambda_1)\,\theta<0.$$

This requires however a corner solution $\lambda_2 = \lambda$, since (16) holds with strict inequality, given that investment is increasing in λ_2. The level of investment associated with this solution would be suboptimal for investors, and it can be shown that welfare would be higher with a lower λ_1, hence there cannot be interior solution for first-period managerial bargaining power. Let us consider the necessary condition for an interior $\lambda < \lambda_2 < \lambda^{\max}$:

$$\beta f'\left(i_t^{\lambda}\right)(1-\lambda_2)\left(\theta+\frac{\delta}{2}\right)-(1-\lambda_1)\,\theta>0.$$

This is also a sufficient condition for the constraint on λ_1 to bind, since in this case the rhs of (15) is negative and the f.o.c. holds with strict inequality. In this case, for optimality of λ_2, (16) must hold with equality since both the direct marginal cost of λ_2 and its net indirect marginal benefit are positive. Note that a corner solution, $\lambda_2 = \lambda$ or $\lambda_2 = \lambda^{\max}$ is still possible.

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