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Information Accumulation in Development

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We propose a model in which economic relations and institutions in advanced and less developed countries differ as these societies have access to different amounts of information. The lack of information in less developed economies makes it hard to evaluate the performance of managers and leads to high "agency costs." Differences in the amount of information have a variety of sources. As well as factors related to the informational infrastructure, we emphasize that societies accumulate information by repeating certain tasks. Poor societies may therefore have less information partly because the scarcity of capital restricts the repetition of various activities. Two implications of our model are (1) as an economy develops and generates more information, it achieves better risk sharing at a given level of effort, but because agents are exerting more effort and the types of activities are changing, the overall level of risk sharing may decline; (2) with development, the share of financial intermediation carried out through market institutions should increase.

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1. Introduction

In this article, we argue that an important difference between developed and less developed societies is the amount of decentralized information that can be exploited by agency relations. Over the course of the development process, societies accumulate information, as well as physical and human assets. As a result, activities that require intensive use of information become more widespread, and the efficiency of a range of economic relations improves. The increasing availability of information can account for a number of salient patterns of institutional change that occur along the development process, including changes in the extent of risk sharing, the development of capital markets, improvements in managerial performance, and changes in the structure of production.

The starting point of our analysis is that delegation of tasks, employment relations, and entrepreneurial activities give a first-order role to principal-agent relations in the organization of production (see, for example, Mokyr, 1991; North, 1990; Pollard, 1965; Stiglitz, 1987). Principal-agent relations fail, however, when information is scarce because in the absence of adequate information, it is excessively costly to give the right incentives to workers, managers and entrepreneurs (for example, Holmstrom, 1979). The amount of decentralized information that the society possesses is therefore an important determinant of the efficiency of economic relations. We model this by allowing the society to use *relative performance evaluation* to judge entrepreneurs' and other agents' performance. More information then enables more accurate relative performance comparisons and improves incentives.

There are a number of obvious determinants of the amount of information in a society—for example, how costly communication is (the number of telephones, efficiency of postal services, information technology), how concentrated business activities are in cities, and so on. We refer to these as the *informational infrastructure* of the economy. Our model enables us to perform simple comparative static exercises with respect to the informational infrastructure of the society. Although many aspects of the informational infrastructure are exogenous to the economy we study, there exists a natural mechanism leading to endogenous changes in the amount of information over the process of development. In less developed economies, capital is scarce and so cannot be allocated in large quantities to all sectors. Therefore, many sectors will have a low-level activity and generate only limited information. As the economy accumulates capital and these sectors expand, the amount of decentralized information will increase, and the principal-agent relations will become more efficient.

Our economy has many sectors (islands). Production in each sector takes place in firms run by entrepreneurs (managers) using capital and labor. The output of each firm depends on managerial effort, an idiosyncratic shock, and a sector-specific shock. The effort choice of the entrepreneur is her private information, introducing a principal-agent problem. She can be induced to exert effort only if her compensation depends on her performance. Since all agents are risk-averse, this is costly. As the capital stock increases, more capital will be allocated to different activities, enabling the parallel employment of more entrepreneurs in each sector. With many entrepreneurs in a sector, average performance can be used as an adequate standard to filter out sector-specific shocks and will ensure better incentives.[1] As a result, the level of entrepreneurial effort and productivity increases with the aggregate capital stock of the economy. In other words, prosperity implies more information, which implies greater efficiency and, in turn again, prosperity. This is a process of growth that would be called a "virtuous circle" by Singer (1949) or "circular cumulative causation" by Myrdal (1968). The mechanism through the accumulation of information and change of incentives is an important, and to date unexplored, alternative to the existing formalization of these ideas.[2] What distinguishes our model is not only the alternative microfoundation for this pattern of virtuous circle but improvements in principal-agent relations that lead to a number of novel implications.

In the second part of the article, we discuss a number of implications of our model. An interesting application concerns the evolution of risk sharing. Many premodern societies and less developed economies had extensive risk sharing arrangements (see, for example, Persson, 1988; Townsend, 1994). More strikingly, Townsend's recent empirical work on Asian village economies finds that the degree of risk sharing is lower in richer villages—"as if consumption insurance, whether indigenous or otherwise, deteriorates with growth" (Townsend, 1995a, p. 95). This finding has sometimes been used to argue that less developed economies have efficient institutions that are destroyed by development. Our model offers a very different explanation for this pattern. We show that more information enables greater risk sharing at a given level of effort but also that with more information entrepreneurs are induced to exert more effort, reducing risk sharing. As a result, risk sharing may decline with growth or follow a U-shape pattern, despite the fact that institutions and economic relations are becoming more efficient. Intuitively, as an economy accumulates more information, the range of activities and the production methods get transformed, and the increase in effort associated with these changes may outweigh the "static" improvements in risk sharing.

A second application concerns the pattern of financial development. In a classic historical study, Goldsmith (1987) shows that institutions to intermediate funds were present in pre-modern societies but were local and relied on direct monitoring. In contrast, today a large fraction of funds are intermediated by stock and bond markets, and even banks, which still play an important financial role, perform little monitoring relative to village "usurers" of older times. The same pattern is observed in a cross-section when the financial institutions of low-income economies are compared to their western counterparts (Besley, 1995). The explanation offered by our model is that when information is scarce regarding how a certain business should be conducted, close monitoring is useful in reducing agency costs. As a larger scale of activity or other factors increase the amount of decentralized information that can be used in incentive contracts, the quality of market signals improve, and institutions that make use of the decentralized information become relatively more attractive. At a stylized level, our model therefore predicts the increasing importance of stock and bond markets in financial intermediation. It also suggests that the decline of other nonmarket institutions engaged in monitoring—such as trade guilds, lodges, and credit cooperatives—may also be related to the accumulation of information over the process of development.

We also discuss a number of other applications of the model developed here. To evaluate which applications are more plausible requires detailed evidence that we do not currently have. So our purpose is only to outline some of the possible economic implications of the mechanism we are proposing.

As the discussion suggests, this article is related to many different strands of the literature. The growth aspect of our model is rather standard. More important for our article is the structure we borrow from information economics. We model relative performance evaluation using the linear structure first introduced by Holmstrom and Milgrom (1987) (hereafter cited as H-M) (see also the applications in H-M, 1991). Models of relative performance evaluation date back to Lazear and Rosen (1981), Holmstrom (1982), Green and Stokey (1983), and Shleifer (1985). The key differences between this article and these contributions are that (1) we construct a general equilibrium model where the amount information used for relative performance evaluation is endogenous and (2) we use these insights to analyze the process of development.

Furthermore, we share with the financial deepening literature the idea that throughout development the structure of financial market changes, and this affects the economic performance (see, for example, Greenwood and Jovanovic, 1990; Greenwood and Smith, 1993; Acemoglu and Zilibotti, 1997; Banerjee and Newman, 1993, 1996). Acemoglu and Zilibotti (1997) share the focus of modeling economic development as a process of changing market incompleteness. However, in that article, we had a model of full information and perfect risk sharing, whereas our focus here is changes in incentives and risk sharing. Banerjee and Newman (1996) explain the migration from villages to cities, based on the assumption that agency costs are less severe in villages than in cities: when agents are poor, they have no collateral and cannot borrow to go cities, and with development these borrowing constraints are relaxed. Accumulation of information is absent in their papers, as in all previous contributions, so their approach is different but complementary to ours.

The plan of this article is as follows: Section 2 describes the environment and characterizes the equilibrium in the absence of imperfect information. Section 3 introduces our micro model of imperfect information, characterizes the equilibria, and performs a number of comparative static exercises. Section 4 determines the impact of capital accumulation on the organization of production and productivity. Section 5 discusses whether the equilibrium is constrained efficient. Section 6 discusses a number of implications of our model. It shows how the extent of risk sharing changes over the process of development, how financial institutions get transformed, and how the composition of output may change. Section 7 concludes and the appendix contains all the proofs.

2. The Model with Perfect Information

2.1. Technology and Preferences

We consider an economy populated by a sequence of one-period lived altruistic generations. Each generation consists of a continuum $N >> 1$ of agents. Throughout her life, each agent inherits and invests her parent's savings, earns labor income, and makes savings decisions. The utility of an agent of dynasty h born in period t is

$$u(c_t^h, b_t^h, e_t^h) = -\exp\left[-\bar{\rho}\left((b_t^h)^s (c_t^h)^{1-s} - \frac{1}{2\overline{\beta}}(e_t^h)^2\right)\right], \tag{1}$$

where e_t^h is effort, c_t^h denotes consumption, and b_t^h denotes the funds left for bequest. These funds are invested at the market rate of return, and the returns accrue to the offspring as bequest. Agents care about the bequest they leave rather than about their offspring's utility (Andreoni, 1989) and preferences over total wealth exhibit constant absolute risk aversion (CARA).

Each agent has a career choice. He can become a worker and earn the wage w or a manager (entrepreneur) and earn the managerial salary z. Total income x is

$$x_t^h = \begin{cases} r_t b_{t-1}^h + w_t & \text{if worker} \\ r_t b_{t-1}^h + z_t & \text{if manager,} \end{cases}$$

where r_t denotes the gross rate of return on savings. Capital depreciates on use; thus r_t is also the net rate of return. Given the separability between the saving and effort, utility maximization implies that $c_t^h = (1-s)x_t^h$ and $b_t^h = sx_t^h$. Thus the warm-glove bequests and Cobb-Douglas preferences ensure a constant savings rate s, which simplifies dynamics. The indirect utility of agent h can then be written as

$$U(x_t^h, e_t^h) = -\exp\left[-\rho\left(x_t^h - \frac{1}{2\beta}(e_t^h)^2\right)\right], \tag{2}$$

where we have defined $\rho \equiv s^s(1-s)^{1-s}\bar{\rho}$ and $\beta \equiv s^s(1-s)^{1-s}\bar{\beta}$. When this will cause no confusion, we will drop superscript h.

There is a continuum υ of islands. Every period there are n agents on each island $j \in [0, \nu]$; thus $N = n \cdot \nu$. Labor cannot be transferred between islands, but capital and final output can. Therefore, each of the n agents in island j will have to work there, but they can invest their capital in any island. Within each island, some of the agents will choose to be managers, while some others become workers. All islands produce exactly the same good.

Production in a firm requires one manager, labor, and capital. The amount of final good produced by firm i in island j at time t, y_{ijt}, is given by

$$y_{ijt} = (\mu + e_{ijt} + a_{jt}) \cdot \min[1, l_{ijt}^{\alpha} k_{ijt}^{1-\alpha}] + \epsilon_{ijt}, \tag{3}$$

where l_{ijt} is total labor hired by the firm inclusive of the manager, k_{ijt} is capital, μ is a constant, e_{ijt} is the effort exerted by the manager of this firm, a_{jt} is an island-specific productivity shock that affects all firms on island j, and ϵ_{ijt} is an idiosyncratic shock that affects only this firm. We think of ϵ_{ijt} as capturing the importance of luck as well as the role of managerial ability ex-ante unknown to the agents. All productivity shocks are independent from each other and over time, and we have $\epsilon_{ijt} \sim N(0, \sigma^2)$ and $a_{jt} \sim N(0, \eta^2)$. The law of large numbers implies (ignoring technical details related to the continuum) that in each period $\int_0^{\nu} a_{jt} dj = 0$ and $\int_0^{\nu} \sum_i \epsilon_{ijt} dj = 0$.

The form of the production function captures the idea that a manager is necessary for production (*division of labor*) and has to exert some effort but that he has a limited span of control. Even though managers have to exert effort, there is no need for workers to exert positive effort (or equivalently, we could assume that workers also have to exert effort but they are perfectly monitored).

Capital is owned and supplied competitively by the agents. As we will see shortly, constant savings rate and CARA preferences over the uncertain-income process imply that wealth effects are absent, so income distribution among agents will not matter for occupational choices and aggregate capital stock dynamics. Therefore, the total stock of capital, K_t, will be the unique state variable of this economy.

Finally, we assume that there exists a large set of potential intermediaries, which we refer to as firms. They can freely enter into any island and are owned at time t by generation t agents. Each active firm rents capital, labor, and one manager in competitive labor and capital markets. We assume that each agent owns an equal share of all of the firms in the economy. Profits and losses are distributed among owners. Since there is no aggregate risk in this economy, an agent who owns an equal share of all firms bears no risk. Therefore, all firms will simply maximize expected profits. It is straightforward to see that if we started from a situation in which some agents owned a small subset of the firms, there would be Pareto improving trades in shares.

2.2. The Equilibrium Concept

Throughout the article we use an extension of the notion of competitive equilibrium that deals with the presence of asymmetric information (along the lines of the notion of *unfettered competition* discussed in Townsend, 1983). In the first stage, potential firms announce in which island, if any, they will be active. If firm i announces at time t that it will be active in island j, we denote this by $i \in \mathcal{M}_{jt}$. We also let $M_{jt} \equiv \#\mathcal{M}_{jt}$ be the number of firms that have announced that they will be active in island j. In the second stage, all $i \in \mathcal{M}_{jt}$ take the first-stage announcements as summarized by $\mathbf{M_t} \equiv \{M_{jt}\}_{j \in [0,\nu]}$ and the total capital stock of the economy K_t as given and compete to hire workers and managers from island j and capital from the economywide market. We restrict each firm to hire at most one manager. We also use ω_t to denote the publicly observed state of nature at time t.

A static equilibrium at time t is a set of first-stage announcements summarized by $\mathbf{M}_t$; factor return functions $w_j(\omega_t; \mathbf{M}_t, K_t)$ and $z_{ij}(\omega_t; \mathbf{M}_t, K_t)$ for all $j \in [0, \nu]$ and $r(\omega_t; \mathbf{M}_t, K_t)$; and labor and capital demands $l_{ij}(\mathbf{M}_t, K_t)$ and $k_{ij}(\mathbf{M}_t, K_t)$ for all $i \in \mathcal{M}_{jt}$ and $j \in [0, \nu]$—such that[3]

1. *Profit maximization* Any firm $i \in \mathcal{M}_{jt}$ for any $j \in [0, \nu]$ chooses l_{ij} and k_{ij} to maximize expected profits conditional on equilibrium managerial effort:

$$\pi_{ijt}(e_{ijt}) = E_t[y_{ijt} - w_j l_{jt} - r k_{jt} - z_{ijt} \mid e_{ijt}],$$

   given $w_j = w_j(\omega_t; \mathbf{M}_t, K_t)$ and $r = r(\omega_t; \mathbf{M}_t, K_t)$ and where $E_t[.|e_{ijt}]$ is the expectation conditional on public information at time t and the level of managerial effort, e_{ijt}.

2. *Market clearing* $w_j(\omega_t; \mathbf{M}_t, K_t)$ for all $j \in [0, \nu]$ and $r(\omega_t; \mathbf{M}_t, K_t)$ are such that

$$\int_{i \in \mathcal{M}_{jt}} l_{ij} di = N, \forall j \in [0, \nu] \tag{4}$$

$$\int_0^\nu \int_{i \in \mathcal{M}_{jt}} k_{ij} di dj = K_t. \tag{5}$$

3. *Occupation choice* All agents are indifferent between becoming workers and managers.

4. *Optimal effort choice* A manager i hired with contract $z_{ij}(\omega_t; \mathbf{M}_t, K_t)$ chooses e_{ijt} to maximize expected utility given by (2).

5. *Optimal contract choice* $z_{ij}(\omega_t; \mathbf{M}_t, K_t)$ is chosen to maximize $\pi_{ijt}(e_{ijt})$ subject to the participation constraint imposed by part 3 of the definition, and e_{ijt} depends on z_{ij} from part 4 of the definition.

6. *Free-entry* $\pi_{ijt}(e_{ijt}) = 0$ for all $i \in \mathcal{M}_{jt}$ and $j \in [0, \nu]$, where e_{ijt} is equilibrium managerial effort as determined by parts 4 and 5 of the definition.

Observe that we have already imposed as part of the equilibrium concept that all firms in island j will pay the same (state-contingent) price for labor and all firms in the economy will pay the same (state-contingent) price for capital. The latter follows from the fact that there is a global capital market with free-capital mobility.[4] The occupation choice condition imposes that managers and workers obtain the same expected utility that follows from unrestricted occupation choice and CARA preferences.[5] With more general preferences, some agents would prefer to enter the more risky occupation, but with CARA all agents have the same tolerance to risk, and in equilibrium all agents will be indifferent between the two occupations. Finally, a dynamic equilibrium is simply a sequence of static equilibria linked through bequest decisions.

We now analyze the equilibrium of this economy under two scenarios:

- *Perfect information* The publicly observed state of nature ω_t includes information about effort choice e_{ijt}. Thus the contract of the manager can be conditioned on her effort level.

- *Imperfect information* Effort choices of managers are not observed by any other agent in the economy. In this case, firms have to obey the incentive compatibility constraints of their managers.

2.3. Equilibrium with Perfect Information

Since output in this economy will be nonrandom and markets are complete, risk-neutral firms will pay nonrandom wages, managerial salaries, and interest rates. Therefore, $w_j(\omega_t; \mathbf{M}_t, K_t) = w_j(\mathbf{M}_t, K_t)$, and similarly for z_{jt} and r_t. Moreover, all agents in the same occupation in island j will receive the same payment, and all firms in island j will hire the same amount of capital and labor. Further, because agents within an island must be indifferent between these two occupations, $z_j(\mathbf{M}_t, K_t) = w_j(\mathbf{M}_t, K_t) + \frac{1}{2\beta} e_{jt}^2$, where e_{jt} is the effort exerted by each manager in island j and $z_j(\mathbf{M}_t, K_t)$ is the salary of the manager conditional on exerting the agreed level of effort, e_{jt}.

Before characterizing the equilibrium occupational choice in each island, we also assume that

$$K_t \geq n^{-\frac{\alpha}{1-\alpha}} \tag{6}$$

holds at time t. This condition ensures that there is enough capital in the economy at time t so that if this capital is allocated equally across all the islands, at least one firm in each island can have $l_{jt}^{\alpha} k_{jt}^{1-\alpha} = 1, \forall j$. When (6) is satisfied, all firms are run with *productive efficiency*, fully utilizing their managerial input. We can now state the following Lemma.[6]

Lemma 1 *Suppose (6) holds at time t and there is perfect information. Then, in equilibrium:*

1. $e_{jt} = e^{fb} = \beta$ *in all islands;*
2. *The equilibrium is symmetric in the sense that capital is equally allocated across islands (for all* $j \in [0, \nu]$, $K_{jt} = K_t$*). The number of firms (managers) that are active in each island is*

$$M_t = M(K_t) \equiv \nu^{-1} N^{\alpha} K_t^{1-\alpha}. \tag{7}$$

   All firms hire the same amount of labor and capital: $l(K_t) = (\frac{N}{K_t})^{1-\alpha}$ *and* $k(K_t) = (\frac{K_t}{N})^{\alpha}$ *so that* $l_t^{\alpha} k_t^{1-\alpha} = 1$*;*
3. *The economywide interest rate and the wage rate and managerial compensation in every island* $j \in [0, \nu]$ *are given by*

$$r(\omega_t; \mathbf{M}_t, K_t) = r(K_t) = (1-\alpha)\left(\frac{N}{K_t}\right)^{\alpha}\left(\mu + \frac{\beta}{2}\right), \tag{8}$$

$$w_j(\omega_t; \mathbf{M}_t, K_t) = w(K_t) = \alpha\left(\frac{K_t}{N}\right)^{1-\alpha}\left(\mu + \frac{\beta}{2}\right), \tag{9}$$

$$z_j(\omega_t; \mathbf{M}_t, K_t) = z(K_t) = \alpha\left(\frac{K_t}{N}\right)^{1-\alpha}\left(\mu + \frac{\beta}{2}\right) + \frac{\beta}{2}. \tag{10}$$

Since information is perfect, managers exert the first-best level of effort $e^{fb} = \beta$, equating the marginal cost of effort to the marginal benefit of higher return from effort (part 1). Decreasing returns to capital ensures that all islands receive the same amount of capital (part 2). From (7), M_t is increasing in K_t. As the amount of capital in the economy expands, the number of managers (firms) increases. Therefore, development is associated with capital deepening and a growing proportion of the agents who choose the managerial occupation. Finally, although output in any particular island is random, thanks to the large number of islands, total output in this economy is nonrandom: $Y_t = \int_0^{\nu} (\mu + e_{jt}) \times \min[1, l_{jt}^{\alpha} k_{jt}^{1-\alpha}] M_{jt} dj = (\mu + \beta) N^{\alpha} K_t^{1-\alpha}$. This ensures that risk-neutral firms can offer full insurance to the factors of production that they hire (part 3). In particular, (8) and (9) state that in equilibrium the expected revenue of each firm net of the additional cost of managerial compensation $(\mu + \frac{\beta}{2})$ is distributed to capital and labor with shares $(1-\alpha)$ and α. (10) ensures that managers get exactly the same expected return as workers.

Given Lemma 1, equilibrium dynamics are straightforward. Since a fraction s of all earnings are saved, the equilibrium capital stock is given by

$$\begin{aligned} K_{t+1} &= sY_t = s(\mu + \beta)\nu M(K_t) \\ &= s(\mu + \beta) N^{\alpha} K_t^{1-\alpha}. \end{aligned} \tag{11}$$

We also assume

$$s(\mu + \beta) > N^{-\frac{\alpha}{1-\alpha}}. \tag{12}$$

This condition—which is always satisfied when N is sufficiently large—ensures that the steady-state level of capital is large enough so that more than one firm per island can be opened, and so it guarantees that the capital stock of the economy does not fall below a certain lower bound. Then

Proposition 1 *Assume that (6) holds at $t = 0$, (12) is satisfied, and there is perfect information. Then there is a unique equilibrium sequence of allocations where in every period, the number of firms, wages, and managerial salaries in each island and the economywide interest rate are given by Lemma 1, and the aggregate capital stock K_t follows (11). K_t uniformly converges to the unique steady-state capital stock, $K^{ss} = [s(\mu + \beta)]^{1/\alpha} N$.*

The equilibrium dynamics of the economy under perfect information are neoclassical: there is accumulation until a steady state is reached, and the rate of return on capital decreases monotonically in the process. Furthermore, given the absence of informational asymmetries, neither the variability of rewards nor the power of incentives change over time. As a result, the behavior of managers and the organization of production are independent of the stage of development. Another important observation is that the number of islands ν is also inconsequential. Since there are constant returns to scale, how many islands there are and how many agents live on each island is irrelevant to capital accumulation and development.

3. The Economy with Imperfect Information

We now assume that the effort choice of a manager is her private information. This introduces standard moral-hazard considerations and implies that managers should be rewarded conditional on their performance and thus will have to receive a random return. We also assume that while the ex-post performance of each individual firm can be costlessly observed, neither the island-specific (a_j) nor firm-specific (ϵ_{ij}) productivity shocks are publicly observed.

We first characterize the equilibrium wages, the rate of return to capital, and the form of equilibrium managerial contracts conditional on the allocation of the capital stock to different islands. We next show that under certain conditions only a unique symmetric equilibrium exist and perform a number of comparative static exercises. We characterize the dynamic equilibrium and discuss constrained efficiency in the next section.

3.1. Static Equilibrium

Let us first define $\zeta_j(\omega_t; \mathbf{M}_t, K_t) \equiv z_j(\omega_t; \mathbf{M}_t, K_t)$ as the return that a manager in island j receives additional to the wage component of her earnings. This return compensates her for the effort of cost and risk taking. In the case of perfect information, there was no risk, and so we had $\zeta_j = \beta/2$. With imperfect information, the manager has to take risks in order to ensure the appropriate incentives, so expected value of ζ_j will be greater than $\beta/2$. We limit attention to equilibria with productive efficiency.[7]

Lemma 2 *Suppose (6) holds at time t. Then, in equilibrium*

1. *For all $j \in [0, \nu]$, the number of firms (managers) that are active in island j is given by $M_j(K_{jt}) = M_{jt}$ such that*

$$M_{jt} = n^{\alpha} K_{jt}^{1-\alpha} \quad and \quad \int_0^{\nu} K_{jt} dj = K_t. \tag{13}$$

All firms in island j hire the same amount of labor and capital: $l_{jt} = l(K_{jt}) = (\frac{n}{K_{jt}})^{1-\alpha}$ and $k_{jt} = k(K_{jt}) = (\frac{K_{jt}}{n})^{\alpha}$ so that $l_{jt}^{\alpha} k_{jt}^{1-\alpha} = 1$;

2. *The economywide interest rate and wages in every island $j \in [0, \nu]$ are*

$$r(\omega_t; \mathbf{M}_t, K_t) = r(\mathbf{M}_t, K_t) = \frac{1-\alpha}{k(K_{jt})} E_t[y_{jt} - \zeta_j(\omega_t; \mathbf{M}_t, K_t)], \tag{14}$$

$$w_j(\omega_t; \mathbf{M}_t, K_t) = w_j(\mathbf{M}_t, K_t) = \frac{\alpha}{l(K_{jt})} E_t[y_{jt} - \zeta_j(\omega_t; \mathbf{M}_t, K_t)]. \tag{15}$$

Part 1 of Lemma 2 is identical to part 2 of Lemma 1, except that under imperfect information the equilibrium does not necessarily have capital equally invested in all islands. Part 2 of Lemma 2, the analogue of part 3 of Lemma 1, states that there is no issue of risk taking by labor and capital (hence r and w_j do not depend on the state of nature ω_t). The large number of islands ensures that there is no aggregate risk, thus risk-neutral firms can once more offer full insurance to the factors for which there in no incentive problem. Therefore, as in the case of perfect information, the expected revenue of firms—net of managerial premium—will be distributed between capital and labor, with shares α and $1-\alpha$. In contrast, managerial compensation is random because individual managers have to bear some risk to provide them with the right incentives. The rest of this section characterizes the contract that determines the managerial compensation.

We start with two observations. First, the economy has a linear structure, normally distributed random variables, and CARA utility. H-M (1987) prove that with this structure and continuous adjustment of effort levels over a continuous segment of time, the optimal contract is linear over cumulative output (see also H-M, 1991, for applications). We appeal to this result and restrict attention to linear contracts.[8] Moreover, CARA preferences and normally distributed returns also ensure that an optimal contract maximizes the certainty equivalent of the income process faced by the principal and the agent. Second, we know from standard agency theory that any variable that contains information about the effort level will be useful in giving incentives to the agent (Holmstrom, 1979). In our economy, average output in island j contains useful information because it is correlated with a_{jt}, and conditioning on a_{jt} is beneficial because the variability generated by this shock reduces the power of incentive contracts. To see the intuition, imagine that firm i in island j performed very poorly. If all other firms in the island did well, this would suggest that the island must have received a favorable shock and the bad performance of the manager is likely to have been due to low effort. In contrast, if all other firms affected by the same shock also performed badly, it is likely that poor performance was due to an adverse island specific shock, not to low effort.

Let us now drop time subscripts. The optimal compensation contract for the manager of firm i in island j takes the form:[9] $z_{if} = \hat{\phi}_{0ij} + \phi_{1ij}(y_{ij} - \mu) + \phi_{2ij}(y_{ij} - y^a_{j(-i)})$ where $y^a_{j(-i)}$ is the average productivity of all jth island firms except firm i—that is, $y^a_{j(-i)} = \frac{\sum_{h \neq i} y_{hj}}{M_j - 1}$. Rewriting this in terms of the additional compensation of the manager, ζ_{ij} (recall $z_{ij} = w_j + \zeta_{ij}$), we have

$$\zeta_{ij} = \phi_{0ij} + \phi_{1ij}(y_{ij} - \mu) + \phi_{2ij}(y_{ij} - y^a_{j(-i)}), \tag{16}$$

where $\phi_{0ij} \equiv \hat{\phi}_{0ij} - w_j$. Note that the compensation of the manager is conditional on the performance of the firm (the term $y_{ij} - \mu$), and the relative performance compared to the average output of all other firms in the same island (the term $y_{ij} - y^a_{j(-i)}$). Expressed differently, (16) is a type of relative performance evaluation contract that sets the average performance of other agents as the benchmark relative to which the manager is judged. As the number of firms in island j (M_j) increases, $y^a_{j(-i)}$ will be more closely correlated with a_{jt}, and the average performance of firms in a particular industry will become a more accurate signal.

The problem of firm i on island j is then equivalent to

$$\max_{\phi_{0ij}, \phi_{1ii}, \phi_{2ij}} E(y_{ij} - \zeta_{ij} - w_j l_j - r k_j | e_{ij} = e^*_{ij}), \tag{17}$$

subject to

$$e^*_{ij} = \arg\max_{e_{ij}} E(\zeta_{ij}) - \frac{1}{2\beta} e^2_{ij} - \frac{\rho}{2} Var(\zeta_{ij}) \tag{18}$$

$$E(\zeta_{ij} | e^*_{ij}) - \frac{\rho}{2} Var(\zeta_{ij}) = \frac{1}{2\beta} e^{*2}_{ij}, \tag{19}$$

where y_{ij} is given by (3) and ζ_{ij} is as in (16). (17) is the expected profit of the firm. The first condition, (18), is the incentive compatibility constraint. It requires that the effort choice of the agent should maximize her payoff given the managerial contract. (19) is the participation constraint that requires that the certainty equivalent of the additional managerial compensation (over and above the wage w_j) should exactly compensate him for the cost of effort. Thanks to CARA preferences, the participation constraint (19) is necessary and sufficient to characterize occupation choice, as implied by the definition of equilibrium.[10]

CARA preferences together with linear contracts simplify the problem, allowing us to proceed in two steps. Because utility is transferable, we can first maximize the sum of the firm's and the manager's utility with respect to ϕ_{1ij} and ϕ_{2ij} subject to the incentive compatibility of the manager, (18). Ignoring terms that do not affect the solution, this maximization problem can be written as

$$\max_{\phi_{1ij},\phi_{2ij}} E(y_{ij}|e^*_{ij}) - \frac{1}{2\beta}e^{*2}_{ij} - \frac{\rho}{2}\, Var(\zeta_{ij}) \tag{20}$$

subject to (18). Next, ϕ_{0ij} can be determined by solving the participation constraint, (19). The following lemma establishes three important intermediate results.

Lemma 3 *Under imperfect information*

1. *Effort choice of manager i in island j is given as*

$$e^*_{ij} = \beta(\phi_{1ij} + \phi_{2ij}), \tag{21}$$

2. *The average productivity of firm i in island j is $E(y_{ij}|e^*_{ij}) = (\mu + e^*_{ij})$, and*
3. *The variance of managerial compensation for manager i is*

$$Var(z_{ij}) = Var(\zeta_{ij}) = \left[(\phi_{1ij} + \phi_{2ij})^2\sigma^2 + \phi^2_{1ij}\eta^2 + \phi^2_{2ij}\frac{\sigma^2}{M_j - 1}\right]. \tag{22}$$

Lemma 3 enables us to fully characterize the set of equilibrium contracts.

Proposition 2 *Suppose (6) holds. Then in equilibrium all managers in island j have contracts $\zeta^*_{ij} = \phi^*_{0j} + \phi^*_{1j}(y_{ij} - \mu) + \phi^*_{2j}(y_{ij} \cdot y^a_{j(-i)})$, where*

$$\phi^*_{1j} = \phi^*_1(K_j) = \frac{\sigma^2}{(M_j\eta^2 + \sigma^2)\frac{\rho\sigma^2}{\beta} + \sigma^2 + (M_j - 1)\eta^2}, \tag{23}$$

$$\phi^*_{2j} = \phi^*_2(K_j) = \frac{(M_j - 1)\eta^2}{(M_j\eta^2 + \sigma^2)\frac{\rho\sigma^2}{\beta} + \sigma^2 + (M_j - 1)\eta^2}, \tag{24}$$

$$\phi^*_{0j} = \phi^*_0(K_j) = \frac{\beta}{2}(\phi^*_{1j} + \phi^*_{2j})^2 + \frac{\rho}{2}\, Var(\zeta^*_j) - \phi^*_{1j}\beta(\phi^*_{1j} + \phi^*_{2j}), \tag{25}$$

and $Var(\zeta^*_j)$ is given by (22), with $\phi_{1ij} = \phi^*_{1j}$ and $\phi_{2ij} = \phi^*_{2j}$.

All firms in island j choose exactly the same managerial contract and this is uniquely determined for given M_j.[11] The dependence of both ϕ^*_{1j} and ϕ^*_{2j} on M_j implies that as the number of firms in island j increases, incentive contracts change. Also, since $e^*_j = \beta(\phi^*_{1j} + \phi^*_{2j})$ (Lemma 3), the organization of production—here captured solely by the level of managerial effort—depends on the number of firms in the island, M_j. The comparative statics in Section 3.3 will establish that $\frac{de^*_j}{dM_j} > 0$. Intuitively, as commented above, when there are more firms, the society can engage in more efficient contractual relations, and this changes managerial incentive increasing effort and productivity. Combining the results of Proposition 2 with those of Lemma 2, we can easily obtain equilibrium factor returns conditional on $\mathbf{M}_t$—that is, conditional on the allocation of capital across islands.

3.2. Symmetric Versus Asymmetric Equilibria

In the perfect information case, equilibrium was symmetric with $K_{jt} = K_t$ (and $M_{jt} = M_t$). With imperfect information, relative performance evaluation and the endogeneity of information introduce an island-specific *externality*. As a result, the equilibrium may involve an asymmetric distribution of the total capital stock across the islands. More specifically, information and incentives improve with the scale of production within an island, and this counteracts decreasing returns to capital in the island. In an asymmetric equilibrium, islands that receive a higher than average amount of investment have higher capital to labor ratios, depressing the rate of return to capital. But at the same time, the larger number of firms improves information and productivity, raising the return to capital.

Lemma 4 establishes that only a unique symmetric equilibrium exists under a simple parameter restriction. We return to asymmetric equilibria in Section 6.4.

Lemma 4 *$\exists\bar{\mu}$ such that for all K_t satisfying (6), $\forall\mu \geq \bar{\mu}$, there exists a unique equilibrium that is symmetric, so that $M_{jt} = M_t = \nu^{-1}N^{\alpha}K^{1-\alpha}$ for all $j \in [0, \nu]$.*

Intuitively, μ is the amount of output each firm produces irrespective of the effort level of the manager. A symmetric allocation maximizes the number of firms, implying that μ is the opportunity cost of allocating capital asymmetrically (that is, of reducing the number of firms). As a consequence, when μ is large, the opportunity cost of an asymmetric distribution of capital is prohibitively high, and there exists only a unique symmetric equilibrium.

3.3. Some Comparative Statics

Equations (23) and (24) imply

$$\frac{d\phi_2^*}{d\sigma^2} < 0, \quad \frac{de^*}{d\sigma^2} < 0;$$

$$\frac{d\phi_1^*}{d\eta^2} < 0, \quad \frac{d\phi_2^*}{d\eta^2} > 0, \quad \frac{de^*}{d\eta^2} > 0;$$

$$\frac{d\phi_1^*}{dM} < 0, \quad \frac{d\phi_2^*}{dM} > 0, \quad \frac{de^*}{dM} > 0.$$

First, when σ^2 increases, ϕ_2^* decreases, and effort and productivity fall. To understand this result, recall that in this economy it is idiosyncratic variability that makes it costly to induce effort. If $\sigma^2 = 0$, managerial contracts would specify $\phi_1^* = 0$ and $\phi_2^* = 1$, and provided that there are at least two firms in the island, managers would bear no risk. Idiosyncratic variability introduces noise to the signal coming from the individual performance and makes managerial compensation random. Since managers are risk averse, this lack of full insurance is costly, and managerial contracts trade off insurance for incentives. As σ^2 increases, the lack of insurance becomes more costly, and there is lower effort in equilibrium. The response of ϕ_1^*, the measure of absolute performance, to changes in σ^2 is ambiguous: it may increase or decrease depending on whether M_j is larger or smaller than $1 + \frac{\sigma^4\rho}{\beta\eta^2}$.

Second, when η^2 increases, ϕ_1^* falls and ϕ_2^* increases, as with more island-specific variability relative performance becomes more informative. Overall, the change in ϕ_2^* dominates, and the net effect is that the level of effort and productivity increase with the volatility of island-specific shocks. Third, when there are more firms to be compared to each other, the quality of market signals improve, and there is more relative and less absolute performance evaluation (higher ϕ_2^* and lower ϕ_1^*). Once more the effect through ϕ_2 dominates, and we have $\frac{de^*}{dM} > 0$. So accumulation of information leads to higher managerial effort and productivity.

3.4. The Importance of Informational Infrastructure

In contrast to the perfect information economy, with imperfect information, the number of islands ν matters for incentives and output. When ν fall (while keeping N constant, so that n increases), the number of managers on each island M increases. The comparative static results of the previous section then imply better incentives and a more efficient organization of production. The reason is that as ν decreases, the number of agents operating within the same economic environment increases, so information exchange becomes more efficient.

A number of factors in practice are equivalent to a reduction in ν. For example, as production becomes more concentrated in cities rather than villages, the consequences for the organization of production and incentives are similar to those of a lower ν. Also, in practice improvements in communication technology (for example, increases in the number of telephones or the introduction of better data management and accounting methods) would enable principals to make more accurate comparisons across agents in different geographic locations, effectively increasing M. So again, the results are similar to those of a reduction in ν.

In this economy ν can therefore be thought as an (inverse) measure of the informational infrastructure. When ν declines, the informational infrastructure improves, and the society can engage in more efficient contractual relations. Hence, as shown by the comparative static results above, ϕ_1 falls and ϕ_2 increases, and managers have better incentives and become more productive.

4. Information Accumulation

In this section we fully characterize the dynamics of accumulation and development with symmetric equilibria and illustrate the process of endogenous information accumulation. Asymmetric equilibria, which are more involved, are discussed in Section 6.

In the case of a symmetric equilibrium, managers in all islands receive exactly the same contract—$\phi_{0jt}^* = \phi_0^*(K_t)$, $\phi_{1jt}^* = \phi_1^*(K_t)$, $\phi_{2jt}^* = \phi_2^*(K_t)$, where ϕ_0^*, ϕ_1^* and ϕ_2^* are given by Proposition 2. They depend on K_t since in symmetric equilibria $M_{jt} = \nu^{-1} N^\alpha K_t^{1-\alpha}$. This also shows that these variables also depend on ν, the measure of the informational infrastructure, which is taken as given in this section. Proposition 2 also implies that in a symmetric equilibrium, all firms in the economy adopt the same capital-labor ratio, and workers in different islands receive the same wage.

Since a fraction s of all income is saved, the law of motion of capital is

$$K_{t+1} = s[\mu + \beta(\phi_1^*(K_t) + \phi_2^*(K_t))]N^\alpha K_t^{1-\alpha}. \tag{26}$$

We can summarize our findings in (proof in the text).

Proposition 3 *Assume that the conditions of Lemma 4 and condition (6) are satisfied. Then, given K_t, there exists a unique symmetric equilibrium allocation at time t. In this equilibrium $M_{jt} = \nu^{-1}N^\alpha K_t^{1-\alpha}$ for all $j \in [0, \nu]$. All managers sign contract (16) with $\phi_0^*(K_t), \phi_1^*(K_t)$ and $\phi_2^*(K_t)$ as given by Proposition 2, and choose effort level as in (21). Factor prices are*

$$\begin{aligned} r(K_t) &= (1-\alpha)(\mu + \beta(\phi_1^*(K_t) + \phi_2^*(K_t)) - \phi_0^*(K_t))\left(\frac{N}{K_t}\right)^\alpha \\ w(K_t) &= \alpha(\mu + \beta(\phi_1^*(K_t) + \phi_2^*(K_t)) - \phi_0^*(K_t))\left(\frac{K_t}{N}\right)^{1-\alpha}. \end{aligned} \tag{27}$$

The evolution of the physical capital stock is given by (26).

Capital accumulation is accompanied by an increase in the number of firms and more repetition. The information that is accumulated as a result of this process improves the effort level of managers and total factor productivity. The interaction of endogenous information and incentives therefore creates a form of "scale externality": a larger stock of capital leads to more information, improving efficiency, and increasing output further. This is a pattern also implied by the older models of the development process as a "virtuous circle," and our theory provides an alternative microfoundation for this pattern of virtuous circle. Because total factor productivity may be increasing in the capital stock over a certain range, dynamics are no longer purely neoclassical, and multiple interior stable steady states cannot be ruled out in general (though it can be established that for μ sufficiently large, the steady state is unique).

If countries differ in the quality of their informational infrastructure (that is, in ν; see Section 3.4), they will converge to different steady states. The informational infrastructure affects both the long-run productivity and the extent of agency costs, as well as the growth rate of these two variables along the transition path. It might also be noted that an increase in the capital stock K_t may improve other dimensions of the economy's infrastructure (for example, increase the number of telephones and reduce ν). This would contribute to the endogenous channel of information accumulation identified in this article and also improve agency relations.

Remark: For some of our applications an economy consisting of different sectors, rather than different islands, may be more appropriate. Our results would apply exactly to an economy where there is a continuum of sectors, each agent has a strong comparative advantage for one sector and the output of different sectors are perfect substitutes. A more realistic formulation would involve different sectors producing *imperfect* substitutes. In this case, aggregate consumption could be defined as a composite of different sectors' output (such as $c_t = \exp[\int_0^\nu \log c_{jt} dj]$), and agents could be homogeneous and decide which sector to work in. This setup—which was analyzed in a previous version of this article—gives similar results, but the analysis is more involved due to "Jensen's inequality" terms in aggregation.

4.1. Agency Costs and Development

Agency costs are costs incurred due to imperfect information in principal-agent relations. In our model these have two components: (1) managers exert less effort in the economy with asymmetric information than in the first best; and (2) they require a risk premium to be compensated for the variability in their income. We capture both of these components with our concept of $TAC(K)$, *total agency costs* that the society incurs per firm:

$$TAC(K) \equiv \left[(\beta - e^*) - \frac{1}{2\beta}(\beta^2 - (e^*)^2)\right] + \frac{\rho}{2}\, Var(\zeta^*), \tag{28}$$

where e^* and $Var(\zeta^*)$ depend on $M(K)$, $\phi_1^*(K)$ and $\phi_2^*(K)$ via equations (13), (21), and (22), and this makes TAC depend on K and ν. The first term of (28) is the effort component, and the second is the loss of utility in certainty equivalent terms due to risk taking by managers.

Another useful concept is $SAC(\bar{e}, K)$ (shadow agency cost), which is given by the certainty equivalent of income that is foregone in order for managers to be induced to exert the effort level $\bar{e}$ (as different from the optimal level of effort, e^*). Formally,

$$SAC(\bar{e}, K) \equiv \min_{\{\phi_1,\phi_2\}} \left[\frac{1}{2\beta}e^{-2} + Var(\zeta)\right] \quad s.t. \phi_1 + \phi_2 = \frac{\bar{e}}{\beta}, \tag{29}$$

where $Var(\zeta)$ is given by (22).

Proposition 4 *Both $TAC(K)$ and $SAC(\bar{e}, K)$ are decreasing functions of the capital stock.*

This proposition establishes that more information is always useful in our setting as it enables better incentives and risk sharing. Therefore, the cost of more effort at the margin and the total loss of utility due to incentive problems are decreasing in the amount of information. As a consequence, as the economy accumulates capital and information, agency costs decline. Similarly, improvements in the informational infrastructure (that is, a decline ν due to better communication technologies or more geographic concentration of economic activities) also increase M and reduce agency costs.

5. Constrained Efficiency

Can a social planner subject to the same technological and informational constraints achieve a more efficient outcome? To answer this question, we analyze the static problem of a planner maximizing the sum of the utility of all agents in the economy without any distributional concern.[12] We start with three simple observations. First, as in the decentralized economy, as long as there is enough capital to open at least two firms with productive efficiency in every island, the planner would never choose productive inefficiency. Second, given our assumptions, the planner will also choose linear contracts. Finally, the planner will offer the same contracts to all managers in the same island. Then the planning problem can be written as

$$\max_{\{\phi_{1j},\phi_{2j},M_j,K_j,e_j\}} \int_0^{\nu} M_j(\mu+e_j)dj - \frac{\rho}{2}\int_0^{\nu} M_j\, Var(\zeta_j)dj - \frac{1}{2\beta}\int_0^{\nu} M_j e_j^2 dj, \tag{30}$$

subject to the incentive compatibility of the managers (18) and the resource constraint (13), with $Var(\zeta_j)$ given by (22).

Proposition 5 *Conditional on* $\mathbf{M}_t$*, the planner chooses* $\phi_{1j}^s = \phi_{1j}^*, \phi_{2j}^s = \phi_{2j}^*$ *and induces* $e_j^s = e_j^*$ *for all* $j \in [0, \nu]$ *as given by equations (21), (23), and (24).*

Conditional on the allocation of capital across islands, the planner would choose the same allocation as the decentralized economy, or in other words, she would choose exactly the same contracts and induce the same level of effort. Although there are many externalities at work, equilibrium contracts are efficient. To understand the intuition of this result, first note that the effort level of a manager does *not* create an externality on other managers in the same island. Given the additive structure of (3), as long as he exerts the expected effort level (a requirement in any pure strategy equilibrium), the signal extraction problem faced by all other firms is unaffected.

Despite the fact that contract choices are efficient, the allocation of capital across islands chosen by the planner does not necessarily coincide with the equilibrium. More specifically, it is straightforward to show, along the lines of Lemma 4, that if μ is sufficiently large (say, greater than $\bar{\mu}^S$), the planner will choose a symmetric equilibrium. Therefore, when μ is larger than both $\bar{\mu}$ and $\bar{\mu}^S$, the unique symmetric equilibrium characterized above is also the constrained efficient allocation. However, it is not possible to establish unambiguously how $\bar{\mu}^S$ compares to $\bar{\mu}$. Intuitively, when a firm decides to locate in island j rather than j', it ignores two externalities due to the information revealed by its location choice: workers in island j will be better off and those in island j' will be worse off because the amount of information, labor demand, and wages are higher in island j and lower in island j'. These two effects do not always cancel out; hence the distribution of capital across islands is not necessarily efficient. Moreover, it is useful to note at this stage that many of the applications we will consider in the next section features technologies or sectors with different degrees of agency costs, and in these situations, the decentralized equilibrium is more likely to be inefficient.

6. Applications

In this section we discuss potential implications of the process of information accumulation. The discussion focuses on our endogenous channel of information accumulation (via capital accumulation), but our results equally apply to improvements information due to declines in ν.

6.1. Evolution of Risk-Sharing

Since workers and capital owners bear no risk, the extent of risk sharing is captured by the variance of managerial returns $Var(\zeta(M(K), \phi_1^*(K), \phi_2^*(K)))$. This is a component of total agency cost (see (28)) analyzed in the previous section. Although $TAC(K)$ decreases with accumulation, the degree of risk sharing may be nonmonotonic or even decreasing with development.

Proposition 6 *Let* $V(K) \equiv Var(\zeta(M(K), \phi_1^*(K), \phi_2^*(K)))$*. Then*

1. *If* $\rho(\sigma^2 + \eta^2) < \beta$*, then* $V'(K) < 0$ *for all* K*;*
2. *If* $\rho\sigma^2 < \beta < \rho(\sigma^2 + \eta^2)$*, then* $\exists \bar{K}$ *s.t.; if* $K < \bar{K}$*, then* $V'(K) > 0$*; and if* $K > \bar{K}$*, then* $V'(K) < 0$*;*
3. *If* $\rho\sigma^2 > \beta$*, then* $V'(K) > 0$ *for all* K*.*

Intuitively, as M (that is, K) increases, shadow agency cost $SAC(\bar{e}, K)$ falls, but in the mean time, the equilibrium level of effort e^* also increases, and this requires managers to bear more risk. This interaction between two opposing forces determines how the variability of managerial returns will change over the development process. Proposition 6 shows that the link between risk sharing and growth depends on the degree of risk aversion and on the amount of noise that contractual arrangements are subject to. For example, if agents have a low degree of risk aversion (small ρ) or the variance of the shocks is small, then, as more information becomes available, risk sharing improves. The opposite occurs when the degree of risk aversion (or idiosyncratic variability, σ^2) is high. In this case, because incentives are very low powered, the variability of managerial returns is limited in poor economies and increases with development. In intermediate cases, the variance is nonmonotonic, and risk sharing increases first and decreases thereafter. Even though only managers bear risks in our economy, the opposing forces impacting on risk sharing will apply more generally to all agents taking risks due to informational problems.

Similarly, improvements in the informational infrastructure will also increase M and create two counteracting forces on risk sharing. Therefore, an economy with a better communications technology may also have less risk sharing than one with less decentralized information.

The possibility that risk sharing is decreasing with accumulation (case 3) or inverse U-shaped (case 2) provides an interesting interpretation to some recent empirical evidence. It is often argued that less developed economies suffer from serious agency problems (see, for example, North, 1990). However, Townsend (1994, 1995a, 1995b) and other recent studies (as reviewed by Morduch, 1995) have shown that in Asian villages there is relatively low variance of consumption and thus quite good risk sharing arrangements. Moreover, Townsend (1995a) finds that risk sharing appears to be *lower* in *richer* villages. It is tempting to interpret these recent findings as evidence that less developed economies do not in fact suffer serious incentive problems and that growth and modernization may be the factors destroying the "efficient" organization of these communities. Our model provides an alternative interpretation to these findings: in less developed economies, the organization of production is highly inefficient, and the high shadow agency costs reduce the equilibrium level of effort. As the scale of economic activity increases, more information becomes available. This induces higher equilibrium effort, and as a consequence the extent of observed risk sharing may decline with growth. Possibly at even later stages of development, information accumulation may bring about lower variability of managerial and entrepreneurial returns and better risk sharing. In Section 6.6, we see that the same result—that the overall degree of risk sharing may decline with development—may also obtain not only due to changes in equilibrium effort but because as shadow-agency costs fall, the composition of output and employment shifts from low to high agency cost activities (such as from agriculture to industry). With the available evidence, it is impossible to determine whether this mechanism is at the root of the decline in risk sharing as these villages grow, though to us the notion that increased incentives and changes in the nature of economic activity associated with growth may destroy some degree of risk sharing seems appealing and realistic.

A related feature worth noting is that our model also has implications about the distribution of (labor) income. Income distribution is determined by the choice of effort by managers and the variability of managerial returns. In cases 2 and 3 of Proposition 6, growth is "unequalizing" in less developed economies because it leads to higher variability of managerial incomes and therefore to a greater difference between the average income of managers and workers. In case 2, however, as capital accumulates further, the variability of managerial returns will decrease, reducing both the observed dispersion among entrepreneurs and the risk premium that managers are paid over workers. If the decline in risk premia dominates the increased compensation for higher effort, growth will imply a more equal distribution of income in advanced economies. Therefore, our model with intermediate levels of risk aversion is consistent with a Kuznets curve.

6.2. Direct Monitoring and Financial Development

At all stages of development, financial institutions intermediate funds from savers to firms. Nevertheless, there are important differences between the institutions in a poor economy and those in a more developed society. In his historical study Goldsmith (1987) finds that in most premodern societies funds are provided by direct lending institutions (such as usurers), local intermediaries, or at best, local banks. This contrasts with the larger banks and stock and bond markets of more developed economies. A crucial difference concerns the degree of direct monitoring carried out by different financial institutions (see, for example, Diamond, 1984, on the monitoring role of financial intermediaries).

In this section, we assume that there are two types of financial intermediaries, with free entry into each type. First, in each island there exist local credit institutions that we call *village intermediaries* (*VI*). These include usurers, credit cooperatives, rotating credit, and savings associations or even trade guilds. These intermediaries collect funds from savers in the whole economy at some market rate r but can only lend to firms located in their own island.[13] The distinguishing feature of *VI*s is their comparative advantage in monitoring (see, for example, Besley, 1995, on the monitoring role of nonmarket institutions). To capture this feature in the simplest fashion, we assume that *VI*s can perfectly monitor the effort of the local managers that they finance. The cost of providing these intermediation/monitoring services is c per firm. Also, for simplicity we assume that monitoring takes place interim so that a *VI* monitors all the managers it lends to before their final performance is revealed.[14] The outcome of monitoring is publicly observed.

Financial intermediation can also be carried out through *global intermediaries* (*GI*) that offer their service at some lower cost but cannot monitor—say, because they lack local expertise. For simplicity, we assume that the cost of providing these services is zero. We can think of these *GI*s as banks that operate at a large scale. Alternatively, since stock and bond markets do not generally provide direct monitoring of firms, we can also think of firms borrowing from *GI*s as raising funds through a stock market. The important assumption here is that, in the absence of informational imperfections, intermediation through *GI* is more efficient than intermediation through *VI*. We also assume that the performance of firms that receive funds via *VI*s is observed by firms run through *GI*, ruling out potential coordination problems.

Clearly, the comparative advantage of local intermediation declines as the scale of economic activity expands and more information is revealed by the activity of firms in the economy. We can prove the following proposition:

Proposition 7 *Let $\hat{K}$ be such that $TAC(\hat{K}) = c$. Then, for all $K_t \leq \hat{K}$ intermediation is provided by "village intermediaries," while for all $K_t \geq \hat{K}$ intermediation is provided by "global intermediaries."*

This result is consistent with the empirical evidence that local financial institutions and other nonmarket institutions providing monitoring services are predominant in poor economies, but decline as development proceeds (see Besley, 1995; Fry, 1995; Goldsmith, 1987). Intuitively, *VI*s do not need decentralized information since they carry out direct monitoring. Therefore, as more information is accumulated, global intermediaries become relatively more attractive. Once again, similar results are obtained when ν falls due to other reasons. Hence, an economy with a better informational infrastructure is more likely to develop a stock market and more modern financial relations. Even though our simple model predicts an abrupt switch from local to global intermediation, the analysis could be easily extended to yield a smoother transition.

6.3. Division of Labor

Division of labor is a complex phenomenon, and different approaches concentrate on different aspects. An important component of the division of labor is the delegation of tasks to agents who are not residual claimants of the returns they generate. In our economy, the most important form of delegation is to have managers running firms. In this extension we show that in poor economies where information is scarce, production techniques that do not rely on principal-agent relationships will have a comparative advantage, and the extent of division of labor will be limited. This view is in line with a simple reading of historical patterns. During the first industrial revolution, firms were predominantly family managed, and this managerial structure is still dominant in many developing economies. More recently, especially starting with the second industrial revolution, complex hierarchical organizations have emerged and played an increasingly important role in production and distribution (see Pollard, 1965; Chandler, 1977).

We analyze the issue of division of labor with a simple extension of our model. We refer to the benchmark technology of production of Sections 2 and 3 as *factory production*

(*FP*). The alternative is *primitive production* (*PP*), which entails no delegation of tasks to a manager. Output of unit i in island j using *PP* is given as

$$y_{ijt} = (\mu + \theta + a_{jt}) \times \min[1, k_{ijt}^{1-\alpha} l_{ijt}^{\alpha}] + \epsilon_{ijt}. \tag{31}$$

Since with *PP* there is no "fixed cost," the number of firms using *PP* is indeterminate. However, to facilitate the discussion and without loss of generality, we impose that for all $i, j, l_{ijt}^{\alpha} k_{ijt}^{1-\alpha} = 1$, so that we can still talk of the "number of firms."

We now assume that $\theta \in (\frac{\beta}{2} - TAC_{\infty}, \frac{\beta}{2} - TAC_1)$ where TAC_m is the total agency cost incurred with factory production when there are m firms in the island. This assumption ensures that when there are very few firms, *PP* is preferred to *FP*. In contrast, when there are sufficiently many firms, agency costs are low, and division of labor (*FP*) is preferred to *PP*. More specifically, when there are m active firms in the island, each firm with *FP* generates a certainty equivalent of income equal to $\mu + \frac{\beta}{2} - TAC_m$ whereas with *PP*, each firm produces a certainty equivalent of income equal to $\mu + \theta$. We can therefore state an analogue of Proposition 7 whereby for any level of the capital stock less than some critical level $\tilde{K}$, the economy does not make use of division of labor, and when $K > \tilde{K}$, all production takes place with *FP*. $\tilde{K}$ in this case is given by $TAC(\tilde{K}) = \frac{\beta}{2} - \theta$. Note also that at the point when the economy switches from *PP* to division of labor, there is an increase in the level of productivity per firm from $\mu + \theta$ to $\mu + e^*(\tilde{K})$ (where $e^*(\tilde{K}) - \frac{e^*(\tilde{K})^2}{2\beta} - \frac{\rho}{2} Var(\zeta^*(\tilde{K})) = \theta$).

It is useful to emphasize that in our economy, the switch from primitive production to division of labor is *not* because division of labor is more capital intensive but because it is more information intensive. In other words, in the absence of informational imperfections, if *PP* were preferred to *FP* at some capital level K_0, it would be preferred at all other capital levels too. Hence, loosely speaking, the division of labor in our economy is limited by the extent of information: when the economy has more capital, and thus more information, agency costs decline and division of labor becomes relatively more attractive.

The analysis of the last two subsections also suggests a more general principal. If more "sophisticated" products or production techniques are at the same time more "information intensive" because monitoring is harder or because they involve more delegation, then as a society develops, the range of products will expand, the production methods will be become more refined, and there will be more delegation of tasks. As in our division of labor example, the productivity will often increase. Naturally, there can be other explanations for some of these changes, for example, because more sophisticated production technique may necessitate more human capital, which is accumulated only slowly. Detailed empirical work may be able to distinguish between these complementary explanations.

6.4. Development and Specialization

Less developed economies are typically highly specialized and invest a large share of their resources in only a few narrow sectors. This is often explained by comparative advantage or by sectorial externalities. Our model offers an alternative explanation for this pattern (with islands viewed as sectors as discussed in Remark 1.). Recall that the analysis of Section 3 showed that asymmetric equilibria are possible with imperfect information,

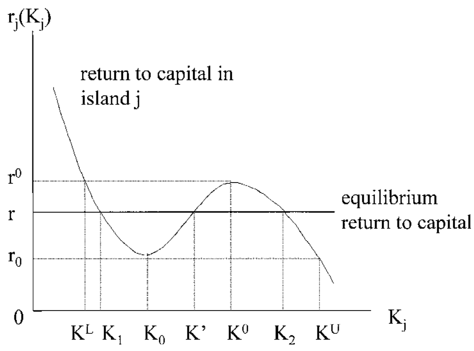

Figure 1. Asymmetric equilibria.

even though with perfect information, there were only symmetric equilibria. Asymmetric equilibria correspond to an economy specialized in a few activities at the expense of the rest. The reason is to economize on agency costs by generating information in some selected sectors. In this section, we analyze asymmetric equilibria and how they evolve with capital accumulation.

The intuition for asymmetric equilibria is as follows. Since the capital market market is unified, the rate of return to capital must be the same in all islands. Labor markets are segregated, however, so workers in different islands may earn different wages. In an asymmetric equilibrium, some islands attract more capital and have lower agency costs, increasing the return to capital. Counteracting this, however, high capital-labor ratios also depress the marginal product of capital. Therefore, the rate of return to capital can be equalized across the islands in an asymmetric allocation of capital, though wages will naturally differ.

To examine the issue more formally, observe that the return to capital in island j, $r_j(K_j)$ (cfr. Lemma 2) can be written in a slightly different way by using the definition of total agency costs *TAC* from equation (28):

$$r_j(K_j) = (1-\alpha)\left(\mu + \frac{\beta}{2} - TAC(K_j)\right)\left(\frac{n}{K_j}\right)^{\alpha}.$$

It is straightforward to show that asymmetric equilibria cannot exist if the $r(K_j)$ schedule is monotonic. In this case, the rate of return to capital can be equalized only if all islands receive the same amount of capital. The condition of Lemma 4 ($\mu > \bar{\mu}$) ensures that the schedule $r(K_j)$ is downward sloping everywhere. But if total agency costs are decreasing steeply in the amount of capital invested in each island, $r_j(K_j)$ may be increasing (see the above equation). The case in which $r_j(K_j)$ is increasing over a certain range is drawn in Figure 1. Note that, due to Inada conditions, $r_j(K_j)$ cannot be increasing everywhere: it has to fall for K_j sufficiently low or sufficiently large. In the particular case drawn in Figure 1, the interest rate is increasing in K in the range $K \in [K_0, K^0]$.

We assume, to simplify notation, that $\nu = 1$. When $K_t \in (K^L, K^U)$, then there exists a continuum of equilibria characterized by the 4-tuple $(r, \underline{K}, \hat{K}, \lambda)$ such that $r_j(\underline{K}) = r_j(\bar{K}) = r$ and $(1-\lambda)\underline{K} + \lambda\bar{K} = K_t$ (where $\lambda \in [0, 1]$). In Figure 1, we illustrate an equilibrium where $\underline{K} = K_1$, $\bar{K} = K_2$, and r is the equilibrium interest rate. Any aggregate capital stock in the range $K_t \in [K_1, K_2]$ is consistent with this equilibrium, and λ is such that $(1-\lambda)K_1 + \lambda K_2 = K_t$. Note that for any such K_t there exist a multiplicity (a continuum) of equilibria. More specifically, any combination of $(r, \underline{K}, \bar{K}, \lambda)$ balancing the two opposing effects, and equalizing the return to capital constitutes an equilibrium allocation.[15] On the other hand, when the aggregate stock of capital is either very high or very low, total agency costs do not decrease at a sufficiently steep rate in the amount of capital invested in each island to make asymmetric equilibria sustainable, and the "neoclassical" effect of capital-labor ratios dominates. In particular, when the aggregate stock of capital, K_t, is lower than K^L or greater than K^U, there is a unique equilibrium that is symmetric—that is, $K_{jt} = K_t$.

Given the multiplicity of equilibria, it is not possible to determine unambiguously how the equilibrium allocation changes as the economy accumulates more capital. A reasonable approach is to select the equilibrium that maximizes the rate of return to capital (for example, because capital owners can coordinate to some degree). In this case, for $K_t \in (K^L, K^0)$, the rate of return to capital is r^0, with an asymmetric equilibrium and for $K_t \geq K^0$, r starts falling and equilibrium becomes symmetric. In this case, when K_t is close to K^L, most sectors have capital K^L, and a few have the higher level of capital K^0. As capital accumulates, the amount of capital received by high capital islands does not change, but the proportion of islands receiving high capital grows. This process of sectorial reallocation stops when the capital stock reaches K^0. As the economy accumulates a sufficiently large stock of capital, there is less need to specialize in a few sectors in order to economize on agency costs, and the economy achieves a more balanced structure. An alternative and weaker equilibrium selection that yields similar implications is to consider a sequence of equilibria with nonincreasing returns to capital (that is, as the amount of capital in the economy increases, the return to capital stays constant or decreases). In this case, as K_t increases, λ, K_1, and K_2 will also increase. Therefore, once again when the economy has relatively little capital, most sectors receive only a small amount of capital, K_1, and with development, the degree of specialization declines.

Overall, our model predicts that even though a specialized economy does not make best use of its factors (due to varying capital-labor ratios), under certain conditions, poorer societies should start out more specialized as a way of economizing on agency costs. Then, as accumulation of information reduces agency costs, the economy would reach a more balanced composition of output.

6.5. Sectorial Transformations

The previous subsection demonstrated that an economy may specialize in a few sectors even though all sectors are ex ante identical. However, in practice sectors typically differ in terms of the structure of uncertainty, the importance of effort and the difficulty of monitoring. This implies that agency problems are more serious in certain sectors than others. When the scale of production is limited, there will be very little information to be used in agency relations, and sectors where agency matters more will have relatively low productivity. As a result, capital accumulation will be accompanied by sectorial transformation toward activities where agency problems are more important.

As discussed above, the variance of idiosyncratic shocks relative to the variance of common shocks is crucial for the extent of agency costs. We assume that a set of islands that we refer to as *agriculture* is subject to large common shocks (weather), while another set of sectors which we refer to as *industry* is subject to more significant idiosyncratic uncertainty (managerial talent).[16]

Let us now develop a very simple version of this sectorial transformation story by making three strong assumptions: (1) There are two goods. We think of the first as an agricultural and the second as a manufacturing (industrial) product. Half of the islands produce only agricultural goods and the other half can produce only industrial goods. On each island $j \in [0, \nu]$ there are N agents that can work only in agriculture, while on each island $j \in [\nu, 2\nu]$ there are N agents that can produce only industrial goods. (2) Agricultural and industrial products are perfect substitutes. (3) The variance of idiosyncratic shocks in agriculture is $\sigma_A^2 = 0$, and the variance for the idiosyncratic shocks in manufacturing is $\sigma_I^2 > 0$. Thus, agency problems are absent in "agriculture."[17] However, note that since $\eta^2 > 0$, agricultural output may be subject to more variability than manufacturing.

The technology is essentially the same as in the one-sector economy. All firms have a quasi-Leontieff technology as in (3). Workers cannot move across islands but can invest their wealth in a balanced portfolio of all the firms in the economy and thus bear no risk.

$$y_{ijt}^A = Z(\mu + e_{ijt}^A + a_{jt}^A) \quad \forall j \in [0, \nu],$$

$$y_{ijt}^I = \mu + e_{ijt}^I + \epsilon_{ijt}^I + a_{jt}^I \quad \forall j \in [\nu, 2\nu],$$

where Z measures the productivity of agriculture relative to industry. Furthermore,

$$a_j^A \sim N(0, \eta_A^2), a_j^I \sim N(0, \eta_I^2), \epsilon_{ij}^I \sim N(0, \sigma_I^2).$$

We also assume, in analogy with the result of Lemma 4, that parameters are such that within each sector there is only a symmetric equilibrium—that is, $M_j^A = M^A$ and $M_j^I = M^I$ for all $j \in [0, \nu]$, though in general $M^A \neq M^I$. Moreover, managerial contracts in agriculture z^A (or ζ^A) differ from managerial contracts in industry z^I (or ζ^I) because of the differences in the structure of uncertainty. Consequently, managerial effort in agriculture e^A will differ from managerial effort in industry e^I. In particular, since the return to agriculture firms within each island are perfectly correlated, the first-best effort level can be implemented in agriculture—that is, $e^A = Z\beta$ and $Var(z^A) = 0$. Instead, industrial contracts will induce the effort level $e^I = \beta(\phi_1^* + \phi_2^*)$, with ϕ_1^* and ϕ_2^* given by (23) and (24). Note that the contract in the industrial sector is conditional on the information generated in the industrial islands.

Let us now write the rate of return on capital in the two sectors, r^A and r^I, when firms make zero profits and labor is paid its marginal product. As in the previous sections, these are given as

$$r^A = \frac{(1-\alpha)Z\left(\mu + \frac{Z\beta}{2}\right)}{k^A}$$

$$r^I = \frac{(1-\alpha)\left(\mu + e^I - \frac{(e^I)^2}{2\beta} - \frac{\rho}{2}\,Var(\zeta^I)\right)}{k^I} = \frac{(1-\alpha)\left(\mu + \frac{\beta}{2} - TAC^I(M^I)\right)}{k^I},$$

where the second equality follows from defining TAC^I as the total agency costs in industry analogously to (28). Since capital is perfectly mobile, all islands face the same interest rate, so $r^I = r^A$, which implies

$$\frac{k^I}{k^A} = \frac{\left(\mu + \frac{\beta}{2} - TAC^I(M^I)\right)}{Z\left(\mu + \frac{Z\beta}{2}\right)}. \tag{32}$$

If there were no agency costs in industry ($\sigma_I^2 = 0$), then $\frac{k^I}{K^A}$ and $\frac{M^I}{M^A}$ would be constant irrespective of the stock of capital of the economy. This implies that the perfect information version of this model would have sector-balanced growth. Next, consider the case with $\sigma_I^2 > 0$. In this case, as capital accumulates, M^I grows and, from (32), $\frac{k^I}{k^A}$ increases. Therefore, there is faster capital deepening in industry than in agriculture. As a result, the shares of industrial production over total production and the share of expenditure in industrial goods over total expenditure also grow with development. Additionally, productivity and wages increase in industry but remain constant in agriculture. As a result, economic growth in the presence of imperfect information is *endogenously sector-biased*, despite the fact that technical progress is neutral across the two sectors. This is consistent with a very salient pattern in the development process: at the early stages of development, a large fraction of resources are allocated to agriculture, and as the economy grows, more resources are transferred to industry. This pattern of development is usually explained by assuming that the potential for productivity growth is much higher in manufacturing than in agriculture due to some "sectorial externalities" (see, for example, Matsuyama, 1991). Our mechanism can be viewed as suggesting a microfoundation for these externalities.

6.6. From Villages to Cities

In the previous subsection, the share of total employment in agriculture remained constant. This feature is easy to change, and the model has interesting implications about migration from "rural villages" to "industrial cities," another salient pattern of economic development. If one introduces an additional factor of production—say, land, which is immobile and assumes, in contrast to previous sections, that labor can move freely between islands—the model predicts that development and information accumulation is accompanied by a decline of total employment in agriculture and migration from "rural villages" to "industrial cities."

The interpretation of the model also suggests another reason why agricultural production may be less information-intensive. Agricultural lands may have low agency costs not only because of the different structure of uncertainty (as in the previous subsection) but also because of the way villages are organized: the close-knit communities lead to tight peer-group monitoring. In contrast, the privacy and anonymity in cities do not allow easy direct monitoring; hence principal-agent relations have to use decentralized information and incentive contracts to induce effort. This point is also emphasized by Banerjee and Newman (1996), who obtain migration from villages to cities as borrowing constraints become less severe. Another implication of the analysis in this section is a slightly different and perhaps more intuitive interpretation of the results of Section 6.1. At the early stages of development, the degree of risk sharing can be very high. This is because the majority of the population works in villages and agriculture where monitoring is easy. As shadow agency costs decline with capital and information accumulation, more agents take advantage of more productive production methods and occupations, but since there is imperfect risk sharing in these sectors due to moral hazard, the observed degree of risk sharing may decline.

7. Concluding Remarks

This article has offered a model of the development process where principal-agent relations play a crucial role. Wealth is generated by delegating tasks to agents who are not the residual claimants of the returns they generate. When the control of these agents is costly, productivity is low. We argue that the amount of decentralized information the society generates is a crucial determinant of how easy it is to control the agents. For example, a better informational infrastructure improves managerial incentives and increases productivity. Perhaps less obviously, better information may also reduce risk-sharing, encourage market-based financial intermediation rather than direct monitoring, increase the division of labor, and affect sectorial and geographical composition of production.

Most important, the structure of information depends on the scale of production. When more agents are engaged in the same activity, the quality of market signals improves, enabling reliable relative performance evaluation. Therefore, as a society accumulates more capital, it also accumulates more information and achieves higher managerial effort and productivity.

Our model has a number of novel implications and features reminding us of the older theories of development with their emphasis on structural transformation. We find that the extent of risk sharing, the sectorial composition of output, the division of labor, and financial institutions will change with development. Besley (1995, p. 121) writes that local institutions and enforcement "do seem in general to disappear as capital markets develop. This reflects the fact that monitoring and other technologies improve in the development process. . . . Whether a symptom or a cause, the decline of this type of non-market institution in the development process vividly illustrates the idea that they use certain information structures and enforcement technologies that are eroded by the transformation to a modern economy." In terms of Besley's statement, our argument is that the relative decline of a host of institutions and sectors is a consequence of information accumulation and development but also that such structural transformations have important implications regarding the range of products, organization of firms, and productivity.

Our model is sufficiently simple and tractable that more results can be obtained by modifying certain aspects of the baseline specification. We hope the issues analyzed in this article give the flavor of the implications changing principal-agent relations in the context of development. We also hope that our model suggests other approaches to the same problem. For example, more information may improve agency relations not only via better relative performance evaluation but also through alternative uses of information, such as better selection and task assignment. Confronting the implications of these approaches with data may improve our understanding of the development process.

Appendix

Proof of Lemma 1

Part 1 Since markets are complete, firms and managers will agree on the first-best level of effort, which, from (2) and (3), is $e_{ijt} = \beta$.

Part 2 We start by showing that k_j, the capital per firm in island j, is a monotonically increasing function of M_j, the number of firms in this island. Given this, we prove that all islands have the same number of firms using proof by contradiction.

First, from profit-maximization, we must have in the second-stage game that $\frac{w_j}{r} = \frac{\partial y_{ij}/\partial l_{ij}^-}{\partial y_{ij}/\partial k_{ij}^-}$ (where the superscript "-" indicates that these are partial derivatives "from below"). Then, from the unitary elasticity of substitution between labor and capital, $\frac{k_{ij}}{l_{ij}} = \frac{k_j}{l_j} = \frac{1-\alpha}{\alpha}\frac{w_j}{r}$ (all firms in island j adopt the same technology). Since when (6) holds all firms are productively efficient ($l_j^\alpha k_j^{1-\alpha} = 1$), it must be the case from (4) that $l_{ij} = l_j = \frac{n}{M_j}$ and $k_{ij} = k_j = \frac{K_j}{vM_j}$. Then, aggregating within each island, we have that

$$\nu^{-1} N^\alpha K_j^{1-\alpha} = M_j, \tag{33}$$

which can be rearranged to give

$$k_j = \left(\frac{K_j}{N}\right)^\alpha \text{ and } l_j = \left(\frac{N}{K_j}\right)^{1-\alpha}. \tag{34}$$

Now, suppose that there are two islands j', j'' such that $K_{j'} > K_{j''}$. (33) implies that $M_{j'} > M_{j''}$. This implies from (34) that $l_{j'} < l_{j''}$ and $k_{j'} > k_{j''}$. Therefore, $\frac{k_{j'}}{l_{j'}} > \frac{k_{j''}}{l_{j''}}$, and because in both island managers exert $e = \beta$, the rate of return to capital in firms of island j' is lower than in j'', contradicting market clearing in the global capital market. Therefore, we must have $K_{j'} = K_{j''} = K_t$ and $M_{j'} = M_{j''} = M_t$. Hence, $l_j = (\frac{N}{K_t})^{1-\alpha}$ and $k_j = (\frac{K_t}{N})^\alpha$.

Part 3 From Part 2, $\frac{rk_j}{w_j l_j} = \frac{1-\alpha}{\alpha}$. Free-entry (zero profits) imply that $rk_j = (1-\alpha)E[y_j - (z_j - w_j)]$ and $w_j l_j = \alpha E[z_j - w_j)]$. Since agents must be indifferent between becoming managers or workers (that is, the participation constraint in the optimal contract choice part of the definition of equilibrium), we must have $z_j = w_j + \frac{e_j^2}{2\beta}$. Now using the fact that $y_j = \mu + e_j$, $e_j = \beta$ and that the symmetry of equilibrium established in Part 2 of the proof, we obtain (8), (9), and (10). This concludes the proof of Lemma 1. ■

Proof of Proposition 1

By assumption $k_0 \geq n^{\frac{-\alpha}{1-\alpha}}$. Then condition (6) ensures that if K_t is in the right neighborhood of $n^{\frac{-\alpha}{1-\alpha}}$, $K_{t+1} > K_t$. Next, given (7), K_{t+1} is an increasing and strictly concave function of K_t and since $M_t \leq n$, we have $K_t \leq s(\mu + \beta)N$. Therefore, there exists a unique steady-state level of K_t, K^{ss}. Since K_{t+1} is a strictly concave function, this unique steady state is also globally stable.

To characterize the steady-state value K^{ss}, note that $K^{ss} = s(\mu + \beta)M(K^{ss})$. Then using (7) gives the expression of K^{ss} in the proposition. The rest of the proposition follows immediately from the analysis discussed in the text. ■

Proof of Lemma 2

Part 1 The proof is identical to the proof of Lemma 1, Part 2, except for the symmetry argument.

Part 2 Since firms are risk neutral, by a standard argument, the equilibrium return of the factors of production for which there are no incentive compatibility constraints will be nonrandom. Therefore, the rates of return to labor and capital are nonrandom. The exact expressions for these rates of return, (14) and (15), follow by the same argument as Part 3 of Lemma 1. ■

Proof of Lemma 3

Part 1 The utility of manager i in island j is given by $U_i(e_{ij,\cdot}) = E(\zeta_{ij}|e_{ij}) + w_j - \frac{1}{2\beta}e_{ij}^2 - \frac{\rho}{2}\,Var(\zeta_{ij}) = \Theta + (\phi_{1ij} + \phi_{2ij})(\mu + e_{ij}) - \frac{1}{2\beta}e_{ij}^2$, where ζ_{ij} is given by (16), and Θ collects terms that do not depend on e_{ij}. Since the manager chooses effort to maximize U_i, we have $e_{ij}^* = \beta(\phi_{1ij} + \phi_{2ij})$.

Part 2 Part 2 is straightforward.

Part 3 $Var(\zeta_{ij}) = E[\zeta_{ij} - \phi_{0ij}]^2 = E[\phi_{1ij}(a_j + \epsilon_{ij}) + \phi_{2ij}(\epsilon_{ij} - \sum_{s\neq i}\epsilon_{sj})]^2 = [(\phi_{1ij} + \phi_{2ij})^2\sigma^2 + \phi_{1ij}^2\eta^2 + \phi_{2ij}^2\frac{\sigma^2}{M_j-1}]$. ■

Proof of Proposition 2

Using Lemma 3, we write the maximization of (20) as

$$\max_{\phi_{1ij},\phi_{2ij}} [\mu + \beta(\phi_{1ij} + \phi_{2ij}) - \frac{\beta}{2}(\phi_{1ij} + \phi_{2ij})^2 - \frac{\rho}{2}\left[(\phi_{1ij} + \phi_{2ij})^2\sigma^2 + \phi_{1ij}^2\eta^2 + \phi_{2ij}^2 \frac{\sigma^2}{M_j - 1}\right].$$

Solving the two first-order conditions gives $\phi_{1ij} = \phi_{1j}^*$ and $\phi_{2ij} = \phi_{2j}^*$ as in (23) and (24). To find $\phi_{0ij} = \phi_{0j}^*$, we use the participation constraint (19) and the facts that $e_{ij}^* = \beta(\phi_{1j}^* + \phi_{2j}^*)$ (from Lemma 3) and $E(\zeta|e_{ij}^*) = \phi_{0j}^* + \phi_{1ij}^* e_{ij}^* = \phi_{0j}^* + \phi_{1ij}^*\beta(\phi_{1ij}^* + \phi_{2ij}^*)$ (from (16)). ■

Proof of Lemma 4

Let us define the rate of return to capital in island j when a total amount of capital K_j is invested there, the labor market clears, and firms choose the optimal contracts and make zero profits as

$$\begin{aligned} r_j(K_j) &= (1-\alpha)(\mu + \beta\phi_1^*(K_j) + \phi_2^*(K_j) - \phi_0^*(K_j) \\ &\quad - \beta\phi_1^*(K_j)(\phi_1^*(K_j) + \phi_2^*(K_j)))\left(\frac{N}{K_j}\right)^\alpha \\ &= (1-\alpha)\mu\left(\frac{N}{K_j}\right)^\alpha \\ &\quad + (1-\alpha)[\beta(1-\phi_1^*(K_j))(\phi_1^*(K_j) + \phi_2^*(K_j)) - \phi_0^*(K_j)]\left(\frac{N}{K_j}\right)^\alpha. \end{aligned}$$

The fact that capital should receive the same rate of return in all islands implies that for all $j \in [0, \nu] : r_j(K_j) = r(\mathbf{M}_t, K_t)$.

A necessary condition for asymmetric equilibrium is that there exist two levels of capital $K_{j'}), K_{j''}$ such that $r_{j'}(K_{j'}) = r_{j''}(K_{j''})$. Therefore, a sufficient condition for the equilibrium to be unique and symmetric is that $r_j'(K_j) < 0$ for all K_j. We will now prove that for μ sufficiently large this is always the case. To see this note that (1) the first term on the RHS of (36), $(1-\alpha)\mu(\frac{N}{K_j})^\alpha$, is decreasing in K_j; (2) the second term of (36), $\Psi(K_j) \equiv (1-\alpha)[\beta(1-\phi_1^*(K_j))(\phi_1^*(K_j)+\phi_2^*(K_j)) - \phi_0^*(K_j)](\frac{N}{K_j})^\alpha$, does not depend on μ; (3) from (23), (24), and (13) it follows that $\exists B^{(u)}$ such that for any $K_j > 0$, $\frac{d\Psi(K_j)}{dK_j} < B^{(u)} < \infty$. Then $\exists\bar{\mu}$ such that $\forall\mu \geq \bar{\mu}$ we have that $r_j'(K_j) < 0$, and there exists a unique equilibrium whereby $\forall j \in [0, 1]$, $K_j = K/\nu$ (the aggregate stock of capital, K, is equally distributed across islands). ■

Proof of Proposition 4

Recall that ϕ_1 and ϕ_2 are chosen to maximize (20) subject to (18). Given the definition of TAC from (28), this is equivalent to the unconstrained maximization of $\mu + \frac{\beta}{2} - TAC(K)$ with respect to ϕ_1 and ϕ_2. Now recall from Lemma 3 that $e^* = \beta(\phi_1^* + \phi_2^*)$ and $Var(\zeta^*) = [((\phi_1^* + \phi_2^*)^2\sigma^2 + (\phi_1^*)^2\eta^2 + (\phi_2^*)^2\frac{\sigma^2}{M-1})]$. Then we can write $TAC(K) = TAC(M(K), \phi_1^*(K), \phi_2^*(K))$. The envelope theorem implies that $\frac{\partial\, TAC}{\partial\phi_1^*}\frac{d\phi_1^*}{dK} = \frac{\partial\, TAC}{\partial\phi_2^*}\frac{d\phi_2^*}{dK} = 0$. Therefore, $\frac{d}{dK}(TAC(K)) = \frac{\partial\, TAC}{\partial M}\frac{\partial M}{\partial K} = -\frac{\rho}{2}(\phi_2^*)^2\frac{\sigma^2}{(M-1)^2}(1-\alpha)\nu^{-1}(\frac{N}{K})^{\alpha} < 0$.

For the second part, from the definition of SAC we have that

$$SAC(\bar{e}, K) = \min_{\phi_2}\left[(\sigma^2 + \eta^2)\left(\frac{\bar{e}}{\beta}\right)^2 + \left(\frac{\bar{e}}{\beta} - \phi_2\right)^2\eta^2 + \frac{\sigma^2}{M(K)-1}\phi_2^2\right].$$

Differentiating this with respect to K and once more using the envelope theorem, we have $\frac{d}{dK}(SAC(\bar{e}, K)) < 0$. ■

Proof of Proposition 5

Conditional on $\mathbf{M}_t$, ϕ_{1j} and ϕ_{2j} are given by the first-order conditions of (30) once e_j is substituted from (18). Straightforward differentiation leads to (23) and (24) exactly as in the decentralized equilibrium. ■

Proof of Proposition 6

From (22), (23), and (24), it follows that

$$v(K) = \sigma^2\frac{(\sigma^2 + (M-1)\eta^2)(\sigma^2 + M\eta^2)}{\left[(\sigma^2 + (M-1)\eta^2) + (\sigma^2 + M\eta^2)\frac{\rho\sigma^2}{\beta}\right]^2}.$$

Let Υ_N denote the numerator and Υ_D the denominator of the right-hand-side expression. Then

$$\begin{aligned} V'(K) &= \frac{\sigma^2\eta^2}{\Upsilon_D^3}\{[(\sigma^2+(M-1)\eta^2)+(\sigma^2+M\eta^2)]\Upsilon_D - 2\left(1+\frac{\rho\sigma^2}{\beta}\right)\Upsilon_N\}M'(K) \\ &= \frac{\sigma^2\nu^4}{\Upsilon_D^3}\left[(\sigma^2 + M\eta^2)\frac{\rho\sigma^2}{\beta} - (\sigma^2 + (M-1)\eta^2)\right]M'(K), \end{aligned}$$

where some straightforward algebra is necessary to go from the first to the second line. Since $M'(K) > 0$, this expression establishes that $sign[V'(K)] = sign[\eta^2 - (1 - \frac{\rho\sigma^2}{\beta})(\sigma^2 + M\eta^2)]$. If $\rho\sigma^2 > \beta$, then $V'(K) > 0$ for all K, which proves part 3. Next, set $M = 1$. If $\rho(\sigma^2 + \eta^2) < \beta$, then $V'(K|M(K) = 1) < 0$, and $V'(K) < 0$ for all K such that $M(K) \geq 1$ (part 1). Finally, if $\rho\sigma^2 < \beta < \rho(\sigma^2 + \eta^2)$, we have $V'(K|M(K) = 1) > 0$, but since $\frac{\rho\sigma^2}{\beta} < 1$, $V'(K)$ is decreasing in M (thus K). Moreover, for M (or equivalently K) sufficiently large $V'(K) < 0$. Therefore, there exists $\bar{K}$ such that for $K < \bar{K}$, $V'(K) > 0$ and for $K > \bar{K}$, $V'(K) < 0$ (part 2). ■

Proof of Proposition 7

First, consider $K_t < \hat{K}$ as defined in the proposition. We will show that all intermediation is through *VI*s is the unique equilibrium. Suppose this to be the case. In this case, free entry ensures that active firms that are using *VI*s make zero profits—that is, $(\mu + \frac{\beta}{2} - c) = w^{VI}(K_t)l(K_t) + r^{VI}k(K_t)$, where w^{VI} and r^{VI} are the equilibrium factor returns when there is only intermediation through *VI*. Now consider a deviation from a firm that decides to use *GI* instead of *VI*. The profit of this firm will be $(\mu + \frac{\beta}{2} - TAC(K_t)) - w^{VI}(K_t)l(K_t) - r^{VI}k(K_t) = c - TAC(K_t) < 0$, since $TAC(K_t) > TAC(\hat{K}) = c$. Hence, intermediation through *VI*s is an equilibrium. We then show that in the same case ($K_t \leq \hat{K}$) all intermediation through *GI*s is not an equilibrium. Assume it is; then free entry in the first-stage game ensures that active firms that are using *GI*s make zero profit—that is, $(\mu + \frac{\beta}{2} - TAC(K_t)) = w^{GI}(K_t)l(K_t) - r^{GI}k(K_t)$. Now consider a deviation from a firm that decides to use *VI* instead of *GI*. The profit of this firm will be $(\mu + \frac{\beta}{2} - c) - w^{GI}(K_t)l(K_t) - r^{GI}k(K_t) = TAC(K_t) - c > 0$. This establishes that there exists a profitable deviation; therefore, intermediation through *GI*s is not an equilibrium. A similar argument would show that no equilibrium in which some firms use *GI*s and some others use *VI*s can exist. Thus, with $K_t < \hat{K}$, intermediation through *VI*s is the unique equilibrium.

Next consider $K_t > \hat{K}$. In this case, the reverse of the previous argument applies exactly, and this establishes that only intermediation through *GI*s is an equilibrium. ■

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Notes

1. Gibbons and Murphy (1990) find that compensation of CEOs depends significantly on the performance of other firms in the same industry, and they interpret this as evidence for relative performance evaluation. Haddlock and Lumer (1994) find a stronger relation using data from the 1930s when companies were much less diversified. There is also informal evidence that decisions to terminate managers and renew loans to entrepreneurs depend on their relative performance.

2. See, for example, Murphy, Shleifer, and Vishny (1989) or Matsuyama (1995) for using interactions in goods markets, Zilibotti (1994) for using credit market problems, and Acemoglu (1997) for using interactions in the labor market.
3. An alternative and equivalent approach has managers hire workers and capital, write coinsurance contracts with each other, and respect incentive compatibility.
4. This is clearly a simplification that is not realistic in the context of developing economies. Nevertheless, there is a significant amount of capital mobility across sectors and regions, and this assumption is the simplest way of capturing this feature while keeping our model tractable. Imperfect capital mobility would strengthen our results but at the expense of substantial complications.
5. Return to capital and managerial compensation are uncorrelated, which simplifies the occupation choice condition.
6. Throughout the article we ignore integer problems and use differential calculus with respect to M_j. However, note that there is a finite number (not a continuum) of firms in each island. Also, there is an additional constraint that $M_j \leq N$ so that the number of firms does not exceed the number of workers on the island. This constraint will be satisfied unless the return to capital is extremely high, and we ignore it in our analysis.
7. As defined in Section 2.3. It is straightforward to see that productive inefficiency cannot arise in equilibrium as long as there at least two active firms in each island. See note 11.
8. See theorem 7 of H-M (1987). Even though we have so far thought of effort as chosen once and for all, our structure would remain unchanged if we considered each period to be a segment of continuous time, and managers continuously adjusted their effort after observing their own and others previous performance. Alternatively, our use of linear contracts can be interpreted as a restriction on the strategy spaces of the agents.
9. Since the manager's compensation depends on the performance of the firm, this formulation is consistent with the manager investing part of his wealth in the project. Note also that with this contract the manager will sometimes have to receive a negative payment. However, for μ large enough this will happen very seldom, and moreover, since there is accumulated wealth, negative payments are not problematic. In what follows, we ignore the constraint that wealth should be nonnegative.
10. In the objective function (17), we have imposed that each firm takes the price of capital r and the price of labor in island j (w_j) as given. This is to be understood as each firm taking the capital stock of the economy K_t and the first-stage announcements of all other firms $\mathbf{M}_t$ as given and anticipating the equilibrium price of capital and the wage rate in island j in the second stage of the entry game (see Section 2.2).
11. As we will see in more detail later, this feature implies that when the number of firms is larger in island j information problems are less severe. This may suggest that it could sometimes be profitable to increase the number of firms by sacrificing productive efficiency. However, the form of our production function (3) precludes this possibility. What matters is not the number of other firms producing in the same island but total production. M_j appears in our expressions because when all firms are run with productive efficiency, total output is proportional to M_j. This also explains the particular form of the production function chosen, (3), rather the alternative $y_{ijt} = (\mu + e_{ijt} + a_{jt} + \epsilon_{ijt}) \times \min[1, l_{ijt}^{\alpha} k_{ift}^{1-\alpha}]$, which would have complicated the analysis.
12. We ignore saving decisions that will depend on the "discount rate" of the planner. We also assume that the informational infrastructure (ν) is a technological constraint that the planner cannot affect.
13. Many intermediaries may have local "expertise" that would justify this. The assumption that *VI*s borrow from savers in the whole economy may not be very realistic. In practice, they can do so by borrowing from other financial institutions. With *VI*s only using funds from their own islands, our analysis would be more involved, but the main result continue to apply.
14. More realistic assumptions, such as stochastic ex post monitoring would not change our main results.
15. More formally, for each $K_t \in [K^L, K^U]$ there exists a range of interest rates that can be sustained as equilibrium. If $K_t \in [K^L, K_0]$ the range of equilibrium interest rates is $[r(K_t), r^0]$; if $K_t \in [K_0, K^0]$ the range is $[r_0, r^0]$; if $K_t \in [K^0, K^U]$ the range is $[r_0, r(K_t)]$. Also, in equilibrium, some islands may receive capital equal to K' as drawn in the figure. However, this equilibrium is not "stable" in response to small deviations of investors and is therefore ignored.
16. The industry versus agriculture interpretation is in accordance with the finding of Townsend (1995a) that individuals involved in entrepreneurial activities suffer more volatile consumption than farmers.

17. All three assumptions can be relaxed. For instance, islands can be allowed to choose whether to specialize in agriculture or industry. Instead of perfect, the two goods may be imperfect substitutes with elasticity of substitution greater than one, and this would also enable us to match the relative price movements over the development process but again is not crucial for our argument. Also, $\frac{\sigma_I^2}{v_I^2} > \frac{\sigma_A^2}{v_A^2}$ rather than $\sigma_A^2 = 0$ would be sufficient in general.

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