

# Agency Costs in the Process of Development

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## Abstract

We analyze an economy where production is subject to moral hazard. The degree of the incentive (agency) costs introduced by the presence of moral hazard naturally depends on the information structure in the economy; it is cheaper to induce correct incentives in a society which possesses better ex post information. The degree of ex post information depends on the number of projects and entrepreneurs in the economy; the more projects, the better the information. This implies that at the early stages of development, the range of projects and the amount of information are limited and agency costs are high. Since the information created by a project is an externality on others, the decentralized economy is constrained inefficient; in particular, it does not ‘experiment’ enough.

The analysis of the role of information also opens the way to an investigation of the development of financial institutions. We contrast the information aggregation role of stock markets and information production role of banks. Because the amount of available information increases with development, our model predicts the pattern of financial development observed in practice; banks first and stock markets later.

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# 1 Introduction

The efficient allocation of resources requires that many tasks be delegated to agents who are not the full residual claimants of the returns they generate. It is therefore natural that agency relations play an important role in many accounts of economic development [e.g. Myrdal, 1968, North, 1990] and that high agency costs faced by some Third World societies have been argued to prevent their economic development [e.g. North, 1990, p. 59]. The change in the factory system at the time of the British Industrial Revolution [see Mokyr, 1991, for discussion], or the emergence of hierarchical organizations and professional management [see Chandler, 1977] are among the agency relations that seem to have played an important role in the process of development. Perhaps the most important example of agency relations is in the credit market. Entrepreneurs borrowing funds for their activities need to be given the right incentives. It is well-known that financial intermediation was limited at the early stages of development, and economic growth and the growth of intermediated funds went hand in hand over the past three centuries [e.g. Goldsmith, 1969, Kennedy, 1987, King and Levine, 1994]. For instance, Goldsmith (1987) shows that in most pre-modern societies financial arrangements were extremely informal, and the same pattern arises from Townsend's (1995) study of Indian villages. These observations suggest that societies at the early stages of development were unable to have wide-ranging agency relations and relied predominantly on family or village ties to raise funds and ensure enforcement. This situation contrasts with the more developed and complex credit relations that we observe today.

A number of other features related to the evolution of incentive contracts and agency relations are also relevant to our investigation. First, while at the early stages most firms were owner managed, the majority of large firms today have management separated from ownership. This suggests that the 'high powered' incentives of the owners have been replaced by the weaker incentives of current day CEOs [e.g. Berle and Means, 1932, Jensen and Meckling, 1976]. Moreover, even when attention is restricted to professional managers only, the same pattern emerges. Jensen and Murphy (1990) show that the pay-performance sensitivity for CEOs has decreased substantially since the 1930s<sup>1</sup>. Second, while in less developed external financing re-

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<sup>1</sup>Unable to explain this pattern using any existing theory, Jensen and Murphy suggest that this is due to political constraints. However, an implication of this explanation is that non-monetary methods of control should be used more often and thus current day CEOs should be replaced more frequently for poor performance. In contrast, Haddlock and Lumer (1994) find that the likelihood

lies almost exclusively on banks and other direct lending relations [Goldsmith, 1987; Fry, 1995], stock and bond markets play an increasingly important role in developed economies. Since banks typically screen and monitor the projects they finance [Diamond, 1984], their diminishing role suggests that the informational requirements of agency relations and thus the form of incentive contracts have been changing over time.

This paper has three related objectives. The *first* is to offer and formalize a simple explanation for why agency costs are high at the early stages of development<sup>2</sup>. Our main thesis is that the information structure of an economy determines agency costs and that over the process of development the information structure changes endogenously. According to North (1990, p. 57), the problem is ‘*to form a communication mechanism to provide the information necessary to know when punishment is required*’. This ‘communication mechanism’ is weak in poor societies and as an economy develops, the flows of information become more efficient and incentives become cheaper to enforce. A direct prediction of our theory is the observed pattern of evolution of incentive contracts: at the early stages of development, large punishments are necessary to induce the right incentives; but as the communication mechanism develops, better risk-sharing (insurance) can be offered to entrepreneurs and other agents, and incentive contracts can become less ‘high-powered’. Our *second* objective is to show that the analysis of agency costs and information has important implications for the development of financial institutions. Our *third* objective is to assess the efficiency of the evolution of agency relations and financial institutions.

As an example of the paper’s main idea, consider the case of an agent who wants to borrow money for foreign trade. Given the amount of risk and uncertainty relative to the behavior of the entrepreneur —e.g. has he picked a good trade, is he putting effort, is he stealing part of the money, was it the weather or carelessness that sunk the ship?—, high agency costs are to be expected. In fact, in pre-modern economies,

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of dismissal has not changed since 1930s.

<sup>2</sup>We should note that the main argument of this paper is about *shadow* rather than *actual* agency costs. The actual agency costs in the villages studied by Townsend may be low because no one engages in entrepreneurship nor invests in risky projects. What is very high is the cost that an agent would have to incur if he decided to borrow money to become entrepreneur, i.e. the agency cost at the margin. Similarly, some aspects of incentives in the complex contemporary organizations may be quite distorted, but absent the relatively efficient information flows of modern society, distortions would be much more serious and perhaps such complex organizations would not exist.

while long-distance trade was an important activity, investors bore a large amount of risk and the risk-premium was very high [see Braudel, 1979]. In contrast, consider a hypothetical situation in which there are many other entrepreneurs borrowing funds for similar foreign trades. In this alternative scenario, investors can reduce the agency costs by using the information they obtain from other entrepreneurs regarding the unavoidable uncertainty of this trade, i.e. in the jargon of the relative performance evaluation literature, *they can filter out the common shock*. This is the story of our paper. At the early stages of development, limited savings constrain the number of projects (or entrepreneurs) as well as the information that can be used to write incentive contracts. Limited information in turn leads to high agency costs. As the capital stock of the economy increases, more entrepreneurs are active and their performance reveals a substantial amount of information to the society, which can be used in devising the right incentives for each entrepreneur. Moreover, we will also argue that the relative scarcity of information at the early stages of development favors banking over stock markets, and that economic development can be associated with a shift from bank finance to stock and bond markets, as observed in practice in the course of financial development.

Our model has three key features: (i) Production requires entrepreneurial effort subject to moral hazard; (ii) Different projects have correlated returns; (iii) The amount of savings determines the number of projects that can be undertaken. As a result, savings determine the amount of information which can be used in devising appropriate incentive schemes for entrepreneurs, and agency costs decrease with accumulation. Expressed differently, in an economy with moral hazard, the compensation of agents depends on idiosyncratic and common shocks which influence their performance, and this lack of full insurance introduces high agency costs. As the economy becomes richer and undertakes more projects, the compensation of agents can be conditioned on the success of other projects, therefore the variability introduced due to common shocks can be largely avoided. In line with this prediction of the model, Gibbons and Murphy (1990) find that the compensation and turnover of CEOs depend significantly on the performance of other firms in the same industry and conclude that there is support for the presence of relative performance evaluations among top executives. Haddlock and Lumer (1994) find even a stronger relation between these variables using data from the 1930s when the U.S. companies were much less diversified than today, thus could more easily be classified to belong to one industry.

Since each project's performance reveals information relevant for others, information has public good features. It is then natural to question the extent to which the market achieves an efficient allocation of resources. To answer this question we contrast the choice of a social planner subject to the relevant informational constraints to the decentralized equilibrium. We show that the social planner would always choose to produce more information than the decentralized equilibrium by 'experimenting'. Further, this constrained inefficiency result is shown to be robust to the formation of complex financial coalitions.

In our economy information is a public good because stock prices of different firms are publicly observed and reveal the performance of each project and thus all the relevant information. In contrast, detailed information regarding projects undertaken within the auspices of a bank is not necessarily publicly observed, and as a consequence banks may be better equipped to deal with the free-rider problems at the early stages of development. The comparison of banks to stock markets leads us to emphasize two *distinct* functions related to information: the first is *information aggregation*, the aggregation of available information, and stock markets are more efficient in this function. The second is *information production* which will depend endogenously on the financial incentives provided by different arrangements. Precisely because the stock market is more efficient at aggregating information, it creates free-rider effects, therefore, it is *not* always good at producing information. This disadvantage of stock markets is more dramatic at the early stages of development when there is less information to be aggregated, and more need to produce additional information. This accords well with the emphasis of a number of economic historians such as Cottrell (1992), Tilly (1992) and Kennedy (1987) who emphasize the role of banks in gathering information over the development process. Therefore, at the early stages of development, as it is observed in practice [Goldsmith, 1987], banks and other non-market institutions are the main channel of financial intermediation. As development proceeds, however, more information can be aggregated and stock markets emerge.

The fact that more information reduces agency costs has been known at least since the work of Holmstrom (1979). However, to our knowledge, endogenizing the information structure is a new step. The main mechanism we propose has some relation to the papers on tournaments and yard-stick competition [Holmstrom, 1982, Green and Stokey, 1983, Lazear and Rosen, 1981, Shleifer, 1985] which also argue that conditioning on the performance of other agents improves incentives, but these

papers treat the number of projects and thus the information structure as given. From a different perspective, Diamond (1984) also discusses the advantages of a large number of projects in a moral hazard setting. Our paper is also related to the literature on rational expectations equilibria, see inter alia Green (1977), Grossman (1979) and Kyle (1989). The closest link is perhaps to Grossman and Stiglitz (1980), where information is a public good and is thus underprovided. However, the information that is relevant in their context is the private information of stock market traders, whereas the role of information in our model is to reduce the costs of agency contracts. Our paper also shares a common ground with the literature on the financial development and growth. Here especially, Greenwood and Jovanovic (1990), Bencivenga and Smith (1991) and Greenwood and Smith (1993) discuss how financial intermediation interacts with growth. Acemoglu and Zilibotti (1995) in a related spirit discuss the interaction between risk-diversification through financial arrangements and growth. Banerjee and Newman (1993,1995) and Aghion and Bolton (1993) propose a mechanism which may also be used to endogenize agency costs. In these papers, the distribution of income is endogenous and it impacts on the form of loan contracts; as the economy develops agents become richer, thus limited liability constraints become less serious. However, this mechanism predicts a pattern opposite to what is observed in practice; as an economy develops, agency contracts should become more ‘high-powered’.

The plan of the paper is as follows. The next section lays out the basic model and characterizes the equilibrium with stock markets. Section 3 characterizes the social planner’s choice and demonstrates that the decentralized equilibrium is constrained inefficient. Section 4 analyzes equilibrium with banking and demonstrates how our model predicts the pattern of financial development observed in practice. Section 5 concludes. An Appendix contains the proofs of the main Propositions and Lemmas.

## **2 The model**

### **2.1 Set up of the model**

#### **2.1.1 Timing of Events and Preferences**

We consider a two-period economy where a large number ( $M$ ) of identical agents only derive utility from second-period consumption. Each agent is risk-averse with

utility given by

$$E_0 U(c_0, c_1, e_1) \equiv E_0 U(c_1, e_1) = E_0 \log c_1^j - v(e_1),$$

where  $c_1$  is second period consumption and  $e_1$  is effort. Also  $v(0) = 0$ ,  $v'(\cdot) > 0$ . Agents who decide to become entrepreneurs will have to exert effort and for all other agents,  $e_1 = 0$ .

The production side of the economy consists of two sectors. The first sector uses unskilled labor as the unique input, and the second sector uses savings and entrepreneurial labor. We will refer to these as the ‘labor-intensive’ ( $x$ ) and the ‘capital-intensive’ ( $y$ ) sectors, respectively. Each agent in the first period of his life has a choice of whether to become an entrepreneur. Agents who decide entrepreneurship spend the first period of their lives acquiring the necessary human capital (at no cost) and in the second period, they run the capital-intensive sector firms. At the end of this period, they receive their salaries and consume this amount. The rest of the agents become workers. They work in the labor-intensive sector during the first period of their lives and receive a wage income. Since there is no consumption in the first period, their whole income is saved and invested in the capital-intensive sector. In the second period of their lives, the workers no longer work; they simply consume the proceedings of their investments from the ‘capital intensive’ ( $y$ ) sector.

Output in the labor-intensive sector of this economy is given by:

$$x = Al,$$

where  $l$  is labor input and  $A$  is aggregate labor productivity. Since all factor markets are assumed to be competitive, the entire output will accrue to the workers. In particular, since all first period income is saved, we have  $w = s = A$  and  $W = S = A(M - \tilde{N})$ , where  $w$  and  $s$  denote respectively wages and savings and capital case letters denote aggregate variables.  $\tilde{N}$ , which will be our key endogenous variable, is the number of agents who decide to become entrepreneurs at time 0.

Production in the capital-intensive sector requires *a project* and *an entrepreneur* to transform the savings of workers into output. The set of available projects is denoted by  $U = [0, N]$ ; each project is represented by an integer and  $N$  ( $M$ ) is a ‘large’ number (that is in our calculations we will let  $N \rightarrow \infty$  and  $M \rightarrow \infty$  such that  $\frac{N}{M}$  is constant). Each project can only be run by one entrepreneur<sup>3</sup>, thus  $\tilde{N}$  is

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<sup>3</sup>More presicely, we assume that if more than one entrepreneur run the same project, they all

also the number of open projects. The level of production in project  $j$  depends on the amount of capital ( $k_j$ ), but there are decreasing returns at the project level [so that in equilibrium not all the funds are invested in only one project]. Also, a firm is productive only if it employs an amount of savings larger than some critical level,  $D$  [see discussion below on this feature]. The production function for an entrepreneur with a project in the capital-intensive sector can be written as;

$$y_j = \begin{cases} \theta Z k_j^\beta & \text{if } k_j \geq D \\ 0 & \text{if } k_j < D \end{cases}$$

where  $\theta \in \{0, 1, \tilde{\theta}\}$  is a stochastic variable whose realization depends on the level of effort of the entrepreneur and on the state of nature. To simplify matters, we assume that each entrepreneur decides between high and low effort, and the utility cost of high effort is  $v(\cdot) = \epsilon$ . Whether the entrepreneur has exerted high effort is observed by no other agent in this economy. The underlying state is also unobservable and it can be *Good* with probability  $p$  and *Bad* with probability  $1 - p$ .

### 2.1.2 Uncertainty.

We assume that the set of projects  $U$  (where  $|U| = N$ ) can be partitioned into three subsets, such that  $U = U_{\{0\}} \cup U_{\{1\}} \cup U_{\{\tilde{\theta}\}}$ , where the cardinality of each of these subsets is, respectively,  $|U_{\{0\}}| = (1 - \pi)N$ ,  $|U_{\{1\}}| = (\pi - \delta)N$ ,  $|U_{\{\tilde{\theta}\}}| = \delta N$ . Each project has an identical probability of belonging to each subset, thus  $\forall j \in U$ ,  $\Pr(j \in U_{\{0\}}) = 1 - \pi$ ,  $\Pr(j \in U_{\{1\}}) = \pi - \delta$ ,  $\Pr(j \in U_{\{\tilde{\theta}\}}) = \delta$ . This feature captures *idiosyncratic* uncertainty in our model. Common shocks are also present as the return of the projects in these subsets will depend on the underlying state of nature. In particular,

- $\forall j \in U_{\{0\}} \Rightarrow \theta_j = 0$ .
- $\forall j \in U_{\{1\}} \Rightarrow \begin{cases} \theta_j = 0 & \text{iff } e_j = \text{low and state is } \textit{Bad}; \\ \theta_j = 1 & \text{otherwise.} \end{cases}$
- $\forall j \in U_{\{\tilde{\theta}\}} \Rightarrow \begin{cases} \theta_j = 0 & \text{iff } e_j = \text{low and state is } \textit{Bad}; \\ \theta_j = \tilde{\theta} & \text{iff } e_j = \text{high and state is } \textit{Good}; \\ \theta_j = 1 & \text{otherwise.} \end{cases}$

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make zero returns. This ensures that there are no property rights over the projects so that the savers will always be paid the full returns. Even if there were property rights and the right to run a project could be traded, these rights would have a price of zero until the point when  $\tilde{N} = N$ , therefore none of our key results would be affected.

Therefore, high effort increases the expected return of a projects in two ways; it reduces the probability of a failure in bad times, and it increases the probability of a very high return in good times. For technical reasons which will become clear soon, we assume that this latter effect is ‘small’, and let  $U_{\{\tilde{\theta}\}}$  be a singleton. This implies that  $\delta = 1/N$ , so the *ex-ante* probability for each project to belong to  $U_{\{\tilde{\theta}\}}$  is infinitesimal. Table 1 summarizes the conditional probabilities of the different realizations for each project.

Table 1. Conditional probabilities of realizations.

Underlying State	Effort	Production level		
		0	$Zk^\beta$	$\theta Zk^\beta$
<i>Good</i> (prob.= $p$ )	High	$(1 - \pi)$	$\pi - \frac{1}{N}$	$\frac{1}{N}$
	Low	$(1 - \pi)$	$\pi$	0
<i>Bad</i> (prob.= $1 - p$ )	High	$(1 - \pi)$	$\pi$	0
	Low	1	0	0

With stock markets, the realization of  $\theta$  for every firm will be publicly observed and this information will be used to form the posterior public belief regarding the underlying state of nature. A better inference of the underlying state of nature will improve the efficiency of contracts that induce high effort and thus reduce agency costs. Intuitively, a stronger punishment of bad outcomes is called for when the state of nature is *Bad* (a failure signals that effort was not exerted with high probability) than when the state is *Good* (a failure is uninformative about whether or not effort was exerted). The reason to introduce the very high realization  $\tilde{\theta}$  is to enable signal extraction in a simple way — with  $\delta = 0$ , when all entrepreneurs exert effort, no information about the underlying state would be revealed. The presence of this very high return implies that when all projects are open, and when all entrepreneurs exert effort, in the *Good* state we would observe one project with return  $\tilde{\theta}Z$  whereas the very high return would not be observed in the *Bad* state. Therefore, when all projects are open and run by high effort, the underlying state would be revealed and the common shock can be filtered out perfectly. The assumption that  $\delta$  is infinitesimal is convenient as it ensures that the effect of  $\tilde{\theta}$  on the aggregate rate of return and on the incentive compatibility condition of the entrepreneurs will be negligible. The important economic point is that when only a few projects are run, signal extraction will be harder, thus, *as the number of projects increases, the inference about the underlying state of nature will improve.*

It has to be noted that there are actually two important features embedded in Table 1. The first is the one discussed in the above paragraph: as the number of projects increases, the information about the underlying state of nature improves. The second feature which will play a crucial role in sections 3 and 4 is that high and low effort have different consequences regarding information revelation. This second aspect will be discussed in detail later.

## 2.2 The Stock Market

At the beginning of every period, a market which we call the *stock market* opens and functions without any costs of transaction. Each entrepreneur makes a contract offer to the market which determines the payment associated with one share (sale price normalized to \$1) of his business in each possible *publicly* observable state of nature. Thus, the contract for entrepreneur  $j$  is a mapping from the space of publicly observable events, denoted by  $\Sigma(n)$ , into real numbers;  $P_j : \Sigma(n) \rightarrow \mathbb{R}$ . After a state of the world  $\sigma \in \Sigma(n)$  is realized, each consumer receives an amount (dividend)  $P_j(\sigma)$  per share. Since the savings used in the capital-intensive sector fully depreciate after use, the capital value of each share after the dividend is zero, therefore  $P_j(\sigma)$  is also the post-realization price of a \$1 share inclusive of the dividend. We assume that it is possible to trade shares in the stock market after the realization of the state of nature and before the dividend payment, and as a result, all agents observe the share price of each ‘firm’ (entrepreneur) and, via the price, they infer the realization of  $\theta$ .

The set of observable events is conditioned upon the fraction of open projects,  $n \equiv \frac{\tilde{N}}{N}$ , because as discussed above,  $n$  will determine the amount of information that is publicly observable. Contracts,  $P$ , are conditional upon the following events: (i) whether the project is successful or not; (ii) what the information revealed about the underlying state is. Although the payment of each share could be conditioned upon the performance of other specific projects, this will not have any information content above and beyond the conditioning upon the *public* assessment of the underlying state. Therefore, when convenient, instead of the overall state of nature  $\sigma$ , we will condition the payments and dividends on a summary measure  $\bar{\sigma}_j$  which is a vector of two elements; the first denotes whether the project in question, project  $j$ , is successful and the second is the public belief about the underlying state of nature. When this will cause no confusion we will drop the subscript  $j$ . The ex-post price

of each share in each state  $\bar{\sigma}$  will be:

$$P_j(\bar{\sigma}) = \begin{cases} \frac{\theta_j(\bar{\sigma})Zk_j^\beta - \omega_j(\bar{\sigma})}{k_j} & \text{if } k_j \geq D \\ 0 & \text{if } k_j < D. \end{cases} \quad (1)$$

Finally, we will assume that all contracts are signed at the same point in time when agents decide their profession, thus an entrepreneur offers a contract to the market and the workers promise to invest a certain amount once they receive their wages [this does not introduce any problems since there is no uncertainty regarding wages]. This assumption will make sure that entrepreneurs compete a la Bertrand and thus obtain no rents above their reservation utility. Also, throughout the analysis it is assumed that entrepreneurs choose their effort level after all contracts are signed<sup>4</sup>.

## 2.3 The decentralized equilibrium

### 2.3.1 The Equilibrium Concept

The concept we will use for the decentralized equilibrium is an adaptation of the notion of Perfect Bayesian Equilibrium to an economy with competing principals. We require that (i) all beliefs be obtained by Bayes' rule, (ii) all entrepreneurs maximize their returns given their contracts and choose the best contract for themselves and (iii) all workers *behave optimally* based on their beliefs taking all other agents' actions as given. In particular, this means that a worker can take the set of open projects and investment levels of other agents and hence the information revealed by these actions as given, and consider a deviation that maximizes his return.

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<sup>4</sup>We have implicitly assumed that shareholders are liable for the project's losses. When the project gives a zero return, the price turns negative and shareholders must pay to the entrepreneur the agreed wage out of their personal income [note that if the consumption of the entrepreneur in the case of a failure were zero, nobody would choose to become entrepreneur since  $\log(0) = -\infty$ ]. An alternative model which would give exactly the same predictions with more notations is one where entrepreneurs can buy insurances against personal failures. Denote the insurance payment that the entrepreneur  $j$  receives in state  $\bar{\sigma}$  by  $i_j(\bar{\sigma})$  and the total compensation of the entrepreneur by  $\omega_j^T(\bar{\sigma})$ . Since there are many projects, the insurance provision can function without any residual risk, thus we have  $\sum_{\bar{\sigma} \in \bar{\Sigma}(n)} i_j(\bar{\sigma}) = 0$ . Also in each state, the total insurance transactions have to sum to zero, thus  $\sum_j i_j(\bar{\sigma}) = 0, \forall \bar{\sigma} \in \bar{\Sigma}(n)$ . Savers observe all insurance contracts of the entrepreneur (*since this is crucial for incentives*). The ex post price of each share would then be:

$$P_j(\bar{\sigma}) = \begin{cases} \frac{\theta_j(\bar{\sigma})Zk_j^\beta - (\omega_j^T(\bar{\sigma}) - i_j(\bar{\sigma}))}{k_j} & \text{if } k_j \geq D \\ 0 & \text{if } k_j < D. \end{cases}$$

It is easy to check that the two models give identical results. In the rest of the paper we will not introduce the insurance market in order to keep the notation simpler.

### 2.3.2 Analysis: Preliminary Results

We first characterize an equilibrium in which a number  $\tilde{N} \leq N$  projects are open and all entrepreneurs choose to exert high effort. We will then determine the equilibrium number of projects  $\tilde{N}$ , and, finally, prove that under some parameter restrictions, the unique equilibrium will entail all entrepreneurs exerting high effort.

Since all projects are ex ante symmetric, without loss of any generality, we will use the convention that if  $j > j'$ , then project  $j$  will open after  $j'$ . We will also suppose throughout the analysis that the number of open projects  $\tilde{N}$  is ‘large’, so that aggregate risk induced by sampling randomness is negligible [that is we are studying the model for the range in which  $A$  is large relative to minimum project size  $D$ ]. This assumption implies that by a law of large number argument, the subset  $\tilde{N}$  of the  $N$  projects which are open will consist (approximately) of a proportion  $\pi$  of projects belonging to  $U_{\{0\}}$  and a proportion  $(1 - \pi)$  belonging to  $U_{\{1\}}$ . Now the maximization problem of a representative saver can be written as

$$\max_{\{s_j\}} \sum_{j, \bar{\sigma}_j} \eta(\bar{\sigma}_j) \log \left( \sum_j P_j(\bar{\sigma}_j) s_j \right) \quad s.t. \quad \sum_{j=1}^{\tilde{N}} s_j = w \quad (2)$$

where  $s_j$  is the amount that savings invested in project (entrepreneur)  $j$ , and  $\eta(\bar{\sigma}_j)$  denotes the probability associated with the state  $\bar{\sigma}_j$ .

Now, consider a situation in which all entrepreneurs offer the same contract,  $P(\bar{\sigma})$ , to the market, and this induces each entrepreneur to exert high effort, and investors decide to invest an equal amount,  $K$ , in each of the  $\tilde{N}$  projects [it is straightforward to show that all equilibria must have this property - details are omitted]. Given high effort in all projects, there are two pieces of information upon which each entrepreneur’s reward will be conditioned. First, the return of his project. Second, whether or not the high return  $\tilde{\theta}Z$  is observed. Let us denote the reward to an entrepreneur by  $\omega \in \{\tilde{\omega}_0, \tilde{\omega}_1, \omega_0, \omega_1\}$ . In particular, let  $\tilde{\omega}_0$  and  $\tilde{\omega}_1$  be the wages paid to the entrepreneur when it is publicly known that the underlying state was *Good* (the high rate of return  $\tilde{\theta}Z$  is observed) and when he is unsuccessful ( $\tilde{\omega}_0$ ) and successful ( $\tilde{\omega}_1$ ); and let  $\omega_0$  and  $\omega_1$  denote the corresponding wages in case the high rate of return  $\tilde{\theta}Z$  is not observed. Once entrepreneurial rewards are defined, the realizations of the ex-post price (or dividends) of each share are determined according to equation (1).

From (1) and (2), the utility of each saver can be written in a simple form :

$$V(n, K) = [p(1 - n) + (1 - p)] \log \left[ \left( \frac{n}{m - n} \right) [\pi Z K^\beta - \pi \omega_1 - (1 - \pi) \omega_0] \right] + \\ + pn \log \left[ \left( \frac{n}{m - n} \right) (\pi Z K^\beta - \pi \tilde{\omega}_1 - (1 - \pi) \tilde{\omega}_0) \right] \quad (3)$$

where we have set  $m \equiv \frac{M}{N}$ , and  $n \equiv \frac{\tilde{N}}{N}$  had already been defined above. Let us explain this equation. The high return  $\tilde{\theta}Z$  is only observed when the underlying state is *Good*, probability  $p$ , and the project with the high return  $\tilde{\theta}$  is open, probability  $n$ . Therefore, the overall probability that  $\tilde{\theta}Z$  is publicly observed is  $pn$ . In this case, the entrepreneurial reward is  $\omega \in \{\tilde{\omega}_0, \tilde{\omega}_1\}$ . Note that since there is effectively only one project with the high rate of return  $\tilde{\theta}Z$ , we leave the determination of this project's contract and contribution to savers' utility out of the analysis [formally, we have  $\tilde{\theta} \rightarrow 1^+$  and  $N \rightarrow \infty$  that makes this the exact solution to our model]. Alternatively, the high rate of return  $\tilde{\theta}$  may not be observed because the underlying state is *Bad*, probability  $1 - p$ , or because the underlying state is *Good*, but the project that would be very successful was not open, probability  $p(1 - n)$ . In this case a reward  $\omega \in \{\omega_0, \omega_1\}$  is paid. Since all entrepreneurs exert high effort, in both underlying states of nature there are  $\pi \tilde{N}$  projects that are successful and pay positive dividends and  $(1 - \pi) \tilde{N}$  which are not successful and pay negative dividends. Finally, there are  $M - \tilde{N}$  savers who will have invested an equal amount in each of the  $\tilde{N}$  open projects, thus we need to divide the revenue by  $M - \tilde{N}$ . Taking logarithms and dividing the numerator and the denominator by  $N$  gives the utility of the representative saver (worker) as (3).

We next write the participation and incentive compatibility constraints that need to hold for a representative entrepreneur to be willing to choose this profession and to exert high effort.

$$(1 - pn)[\pi \log \omega_1 + (1 - \pi) \log \omega_0] + pn[\pi \log \tilde{\omega}_1 + (1 - \pi) \log \tilde{\omega}_0] - e \geq V(n, K) \quad (4)$$

$$(1 - p)\pi(\log \omega_1 - \log \omega_0) \geq e \quad (5)$$

The first constraint is for participation. The left-hand side is the entrepreneur's expected utility and since the entrepreneur can decide to become a worker this has to be no smaller than  $V(n, K)$ . Note that all agents are free to become savers, therefore (4) requires the utility of an entrepreneur to be greater than the *maximized* value of a saver. This makes the problem somehow non-standard in that it is no

longer a simple constrained maximization but a fixed-point problem. The second constraint is for incentive compatibility. It requires that the entrepreneur has higher expected utility from high effort than from low effort. In other words, it requires the loss of utility from lower rewards in the case of low effort to be less than the cost of high effort.

In equilibrium,  $P(\bar{\sigma})$  and  $\omega(\bar{\sigma})$  are determined by maximizing (3) subject to the participation constraint (4) and the incentive constraint (5) with respect to  $\omega_0, \omega_1, \tilde{\omega}_0$ , and  $\tilde{\omega}_1$ . Proposition 1 summarizes the results [the proof of this Proposition together with all other proofs is in the Appendix].

**Proposition 1** *In an equilibrium where all entrepreneurs choose high effort:*

1. *The constraints (4) and (5) hold with equality.*
2. *Each entrepreneur receives the following rewards:*

$$\omega_0 = \frac{E \left( \frac{B}{G^\pi} \right)^{(1-pn)} \frac{n}{m-n} \pi Z K^\beta}{1 + E \left( \frac{B}{G^\pi} \right)^{(1-pn)} \frac{n}{m-n}} B \quad (6)$$

$$\omega_1 = G\omega_0$$

$$\tilde{\omega}_1 = \tilde{\omega}_0 = B\omega_0$$

where  $G \equiv \exp \left[ \frac{e}{(1-p)\pi} \right] > 1$ ,  $B = \pi G + (1 - \pi) > 1$ , and  $E = \exp\{e\} > 1$ .

3. *Savers obtain the safe return  $\frac{n}{m-n}(\pi Z K^\beta - B\omega_0)$ .*
4. *The expected utility obtained by all agents is equal to*

$$V(n, K) = \log(\pi Z K^\beta) - \log \left( \frac{m}{n} + E \left( \frac{B}{G^\pi} \right)^{(1-pn)} - 1 \right) \quad (7)$$

with partial derivatives  $V_n(n, K) > 0$  and  $V_K(n, K) > 0$ .

As the expression for the safe return shows,  $B\omega_0$  can be interpreted as the average (per project) cost of entrepreneurship borne by the savers. Furthermore, from equation (7) we can observe that  $\left( \frac{B}{G^\pi} \right)^{(1-pn)}$  is the cost incurred due to the fact that the entrepreneur is not getting full insurance; instead, with probability  $(1 - pn)$ , he receives a salary that depends on the outcome of the project and hence he is bearing

some risk. As  $n$  increases this probability and the associated costs will go down. Finally, notice that savers are fully insured due to the fact that conditional on high effort by all entrepreneurs, there is no aggregate uncertainty. This is a very useful feature as it enables us to completely isolate the impact of information on agency costs by removing the interactions between aggregate uncertainty and agency costs.

### 2.3.3 The Number of Projects:

Next, we characterize the choice of  $K$  and  $n$  still assuming that in equilibrium all entrepreneurs exert high effort.

**Assumption 1**  $\frac{1-\beta}{\beta}m > E \left[ \left( \frac{B}{G^\pi} \right) - 1 \right]$ .

This condition implies that decreasing returns to capital in each project are sufficiently strong (low  $\beta$ ), compared to the effort cost. It therefore guarantees that, if possible, to open a new project and pay the compensation to one more entrepreneur will always be more profitable than to expand the scale of production in existing firms. In the absence of this assumption none of our qualitative results would be affected, but restricting attention to this set of parameter values simplifies the exposition.

Recall now that aggregate savings,  $S$ , is equal to the wage income of the previous period. Then:

**Proposition 2** *Suppose Assumption 1 holds. Then, in an equilibrium with high effort:*

- (i) If  $\frac{A}{A+D} < \frac{N}{M} \Rightarrow S = \frac{A}{A+D}DM$ ,  $k_j = D$ , and  $\tilde{N} = \frac{S}{D}$ .
- (ii) If  $\frac{A}{A+D} \geq \frac{N}{M} \Rightarrow S = A(M - N)$ ,  $k_j = \frac{S}{N}$ , and  $\tilde{N} = N$ .

Therefore, the maximum number of projects which is consistent with the technological constraints will be opened in a high effort equilibrium, and as the stock of savings increases more projects will be undertaken. Once all the projects are open, expansion will follow in the form of higher investment in each project. As a consequence the level of savings determines the number of projects which in turn determines how much information becomes publicly available and thus how costly it is to induce the right incentives. Since the level of savings is a one-to-one function

of the level of labor productivity,  $A$ , we will do our comparative static analysis with respect to  $A$  (or interchangeably with respect to  $S$ )<sup>5</sup>.

**Proposition 3** *Let  $\bar{\omega}$  denote the entrepreneurial wage with contractible effort. Define the agency costs by the ratio,  $\left(\frac{B\omega_0}{\bar{\omega}}\right)$  [recall equation (4)]. Then, agency costs are a decreasing function of the aggregate stock of savings.*

At the early stages when  $S$  is low,  $n$  is also low and thus agency costs are high. In richer economies, the number of projects which can be financed is larger, there is better information and thus agency costs are lower. This is one of the key results of our analysis. It demonstrates that, as often claimed informally, e.g. North (1990), development goes hand in hand with the reduction of incentive (agency) costs and the reduction in these costs at the later stages is due to an improvement in the information structure of the economy. Moreover, as the economy develops,  $n$ , the probability that the underlying state is discovered increases and because when the underlying state is *Good*, we have  $\tilde{\omega}_0 = \tilde{\omega}_1$ , and together with development, the agent will bear less risk and the incentive contracts will become less and less ‘high-powered’. This is in line with the evidence discussed in the introduction.

## 2.4 High Effort as Equilibrium

We now prove that as long as the cost of effort is not too high, in the decentralized equilibrium all entrepreneurs choose high effort.

**Assumption 2**  $E\left(\frac{B}{G^\pi}\right) < \frac{M}{N} \frac{1-p}{p} + 1$ .

We also introduce some additional notation:

- $\rho$  denotes the probability of discovering ex post that the underlying state has been *Good* conditional on the actual state being *Good*.

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<sup>5</sup>Note that while the model is static, to extend these results to a growing economy is straightforward. In Acemoglu and Zilibotti (1996a), we consider an overlapping generation model, and assume that production in the capital-intensive sector exerts a positive externality on the labor productivity of the labor-intensive sector, such that  $A_t = BY_t$ , and  $A_t$  is the state variable of the model. In this case, the model exhibits standard neoclassical dynamics with convergence to a stationary steady-state. Along the transitional path towards the steady-state,  $\tilde{N}$  grows and agency costs fall as  $A_t$  and the stock of savings increase. Therefore, all results can be easily re-interpreted in the context of a growing economy (an earlier version with the details is also available on request from the authors).

- $V(n, K|\rho)$  denotes the indirect utility of each worker conditional on  $\rho$ , with all entrepreneurs exerting high effort.
- $b(n, K|\rho)$  and  $b^{le}(n, K|\rho)$  respectively denote the average return of *one project* net of the salary paid to the entrepreneur conditional on high effort and low effort.

Let us now establish that the return to a representative saver in the case of high effort for all projects is increasing in the amount of available information.

**Lemma 1** *Consider an allocation in which all entrepreneurs choose high effort. Then  $\forall \rho' > \rho$ ,  $V(n, K|\rho') > V(n, K|\rho)$  and  $b(n, K|\rho') > b(n, K|\rho)$ .*

**Lemma 2** *Suppose Assumption 2 holds, then  $b(n, K|\rho) > b^{le}(n, K|\rho)$ ,  $\forall \rho$ .*

With low effort, the cost of effort and the related agency costs are not incurred. The rate of return of the project is lower. Lemma 2 establishes that - *leaving aside informational issues* - the first effect is outweighed by the second, and savers receive a higher return from a high effort project than from a low effort project.

**Proposition 4** *Suppose Assumptions 1 and 2 hold. Then, the allocation characterized in Propositions 1 and 2 is the unique equilibrium.*

Given Assumption 2, high effort has higher return and this induces each entrepreneur to offer a contract that promises high effort. To see the intuition, suppose that an entrepreneur offered a contract that would make him choose low effort, because the rate of return from this project would be lower than the alternatives, each saver would prefer to invest in other projects. Therefore, the entrepreneur with low effort would not be able to raise enough funds.

We conclude this section with two remarks about the robustness of our specification. First, in our formulation agency costs decrease as the number of firms grows, because the probability of observing the fully revealing signal,  $\tilde{\theta}$ , is increasing in the number of firms. The same mechanism, that the inference of the underlying state improves with the number of firms, would work more generally as long as the number of possible realizations of the underlying state were of the same order as the number of projects. Our specification with just two underlying states and a very large number of projects captures this mechanism in a parsimonious way. Second, our

results depend on some form of technological non-convexity. If all the projects can be opened at all stages of development, then there would be no dynamics in agency costs. However, the assumption of minimum size requirement in the production function (that is, for  $k < D$ ,  $y = 0$ ) is inessential as there is already a non-convexity arising from the fact that each project requires one entrepreneur who needs to be given exactly the same return as the savers. Thus, removing this assumption would not alter our qualitative results, but it would complicate the analysis because the equilibrium size of projects in this case would depend on the number of projects. The discontinuity at  $D$  enables us to keep the project size constant irrespective of the number of projects are open.

### 3 Constrained Inefficiency

#### 3.1 Constrained Efficiency and Experimentation

We have now established that decentralized equilibrium induces all entrepreneurs to choose high effort. However, this may not be optimal since low effort produces different information than high effort. This is the second feature embedded in Table 1; if a project that has exerted low effort is successful, we discover that the state of nature has definitely been *Good*. Although the exact link between effort and information revelation is a special feature of our model, it is an example of a more general issue; the trade-off between the private return and the amount of socially useful information which is revealed by different production techniques. We can think of choosing low effort in this setting as *experimentation* because it has a lower direct return than high effort but it has the potential of revealing socially useful information. This feature is considerably more general than our formalization: for instance, consider a more complex matrix of actions and payoffs than Table 1: some actions would require high effort, and a subset of these would have lower private return but reveal more information. The actions that reveal more information would play the same role as low effort in our example.

We now analyze the choice of a social planner who maximizes the welfare of a representative agent subject to the same informational constraints as the decentralized economy. Namely, the social planner will directly observe neither the underlying state nor the effort choices of the entrepreneurs. Under this informational constraint, the planner will choose and announce the set of contracts that will be offered to the

agents who decide to become entrepreneurs<sup>6</sup>.

**Proposition 5**  $\exists S_h < DN$  such that;

- (i) If  $S < S_h$ , the social planner would induce no effort in  $r$  projects and high effort in the remaining  $\tilde{N} - r$  projects, where  $0 < r < \tilde{N}$  and  $\tilde{N} = \frac{S}{D}$ .
- (ii) If  $DN > S \geq S_h$ , then the social planner would induce high effort in all  $\tilde{N} = \frac{S}{D}$  open projects ( $r = 0$ ).
- (iii) If  $S \geq DN$ , then all  $N$  projects are open and  $r = 0$ .

This proposition states that the social planner would choose to *experiment* at earlier stages of development when the stock of savings (or labor productivity) is low. Low effort yields a lower return, thus everything else being equal, choosing low effort is costly. However, if low effort is chosen and the project is successful, we discover that the underlying state of nature is *Good*. Therefore, investing in low effort projects is equivalent to *social experimentation* because it increases  $\rho$ , the probability that the society discovers the state of nature. Since for  $S < S_h$ , the constrained efficient allocation has  $r > 0$ , the decentralized equilibrium is constrained Pareto inefficient in this range. However note that even in the social planner's choice we have the feature that the amount of information available to the society on which incentive contracts can be conditioned increases along the process of development, thus agency costs are still decreasing in  $A$  and  $S$ .

### 3.2 Impossibility of Experimentation in Equilibrium

The previous subsection demonstrated that the constrained efficient allocation involves some degree of *experimentation*. However, we know from section 2 that with the stock market such an allocation is not sustainable. Yet this is partly due to the fact that the stock market set-up forces each entrepreneur to act alone and thus provides no means for internalizing the *informational externality*. A possible intuition is that financial coalitions can form in order to internalize this externality [see Boyd and Prescott, 1987 who suggest financial coalitions as a solution for a different type of externality]; for instance, a group of entrepreneurs can get together and offer shares as an investment fund. Then, it may be conjectured that some positive

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<sup>6</sup>Note also that we are still maintaining the assumption that  $\tilde{N}$  is large or that  $n$  is not infinitesimal. This is equivalent to assuming that the level of savings  $S$  is not too small. If  $\tilde{N}$  were small, then the social planner would again prefer not to experiment. For instance, when  $\tilde{N} = 1$ , there is obviously no point in experimenting.

amount of *experimentation* can be sustained as an equilibrium. We will show that this conjecture is not correct.

We model the formation of financial coalitions among entrepreneurs through financial intermediaries (or investment funds). A financial intermediary can costlessly ‘run’ any number of projects and offer a dividend stream that combines the returns of all these projects. There exist a finite number  $I$  of financial intermediaries assumed to maximize profits and compete a la Bertrand, thus in equilibrium all intermediaries will make zero profit<sup>7</sup>. More specifically, we assume that intermediary  $i$  offers a set of contracts  $\langle \omega_j^i \rangle$  to each of the entrepreneurs it deals with [that is for each  $j \in J_i$ ] and an investment package (fund) to the market which is again a mapping from the observable states to a payment level for each \$1 invested. Thus we have  $\omega_j^i : \Sigma(n) \rightarrow \mathbb{R}^+$  and  $P^i : \Sigma(n) \rightarrow \mathbb{R}$ , with  $P^i(\sigma)$  as the amount the investor who put \$1 will get in state  $\sigma$  and  $\omega_j^i(\sigma)$  as the amount that entrepreneur  $j$  gets in state  $\sigma$  if he accepts the contract. The amount  $\sum_{j \in J_i} \theta_j(\sigma) Z \pi k_j^\beta - P^i(\sigma) - \sum_{j \in J_i} \omega_j^i(\sigma)$  is the profit of the intermediary  $i$  in state  $\sigma$ . If an intermediary runs a large number of projects, then in equilibrium, it can diversify all the idiosyncratic risks. In the rest of this section, we suppose without loss of any generality that all intermediaries actually do this, therefore they bear no risk.

With this set-up and the equilibrium concept we have used so far, it can be shown that there exists no equilibrium in the range of saving levels ( $S < S_h$ ) where some amount of experimentation is socially desirable. This result will be formally stated and proved in Proposition 6; here we briefly discuss the intuition and relate it to the existing literature. First, the presence of free-entry makes experimentation impossible. If an intermediary engages in experimentation, it also needs to run some other projects with higher returns to cover the costs of experimentation. However, another financial intermediary can then bid away the profitable projects who are cross-subsidizing the low effort entrepreneurs and leave only the loss-making experimentation project(s) to the first intermediary. Therefore, even with complex financial coalitions, competition and public availability of information make sure that any intermediary engaging in costly information creation will not be able to enjoy the *monopoly power required to cover its losses on the other projects*. Next, an allocation without experimentation cannot be an equilibrium either since a financial

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<sup>7</sup>For off-the equilibrium path behavior, we assume that all financial intermediaries are jointly owned by all the agents in the same generation and if they make profits or losses, these will be distributed equally among the  $M$  agents.

intermediary can do better than this allocation (through some degree of experimentation) and attract a large portion of the funds. So, no equilibrium exists. This non-existence result is related to Grossman and Stiglitz (1980) and Rothschild and Stiglitz (1976). In Grossman and Stiglitz, the information of stock market traders is revealed by the market price. This implies that no trader wants to incur the costs of gathering information, thus no information is revealed and no equilibrium exists. In contrast to Grossman and Stiglitz, in our economy the non-existence problem only arises when financial coalitions are introduced. This is in a sense natural since introducing financial coalitions is equivalent to looking for a coalition-proof equilibrium in the original game [see Bernheim, Peleg and Whinston, 1987 for a definition] and such an equilibrium does not exist in general. Also, in Rothschild and Stiglitz's (1976) paper, entry can always destroy a pooling equilibrium by stealing away profitable types and this has the same consequences as a financial intermediary stealing high effort projects and free-riding on the information created by the low effort projects in our model. However, it has to be noted that again in Rothschild and Stiglitz, the non-existence problem arises without coalitions and also that non-existence problems in adverse selection models as theirs is much more common than in moral hazard models as ours.

We will now show that as in Rothschild and Stiglitz's insurance model a natural refinement of our original equilibrium concept, *Reactive Equilibrium*, is sufficient to restore a *unique equilibrium* which coincides with equilibrium outcome of Propositions 1 and 2, where all entrepreneurs exert high effort. Intuitively, according to our previous equilibrium concept, to disturb equilibrium it was sufficient for an entrant to make positive profits given the set of existing financial contracts. Whereas the Reactive Equilibrium imposes the additional requirement that the entrant should not be subject to *yet another round of entry* which would make her incur *negative profits*<sup>8</sup>.

Before providing the formal definition, we introduce the following notation.  $C$  denotes a set of contracts offered to savers by a financial coalition.  $\Pi(C|C \cup C')$

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<sup>8</sup> A game theoretic justification for this equilibrium concept is given in Acemoglu and Zilibotti (1996b). Briefly, consider a game in which financial intermediaries are sequentially offering contracts or are withdrawing the contracts that they have previously offered. An equilibrium is reached when no intermediary wants to withdraw or make a further offer. We show that for any cost of withdrawing contracts  $\epsilon > 0$ , there is a unique equilibrium which is the same as the Reactive Equilibrium. It is significant to note that Wilson's (1979) equilibrium concept, which is in spirit very different than Reactive Equilibrium, was motivated by intermediaries withdrawing their contracts from the market but, in our game, this equilibrium only exists when  $\epsilon = 0$ .

denotes the profits of the intermediary that offers  $C$  when also  $C'$  is offered in the market. Then:

**Definition 1** *A vector of contracts  $\{C_i\}$  is a Reactive Equilibrium iff*

- (i)  $\{C_i\}$  is feasible; all agents are optimizing conditional on  $\{C_i\}$ , all beliefs are derived by Bayes' rule, and  $\forall j, \Pi(C_j|\{C_i\}) \geq 0$ .
- (ii)  $\forall C' : \Pi(C'|\{C_i\} \cup C') > 0, \exists C'' : \Pi(C''|\{C_i\} \cup C' \cup C'') > 0$ , and  $\Pi(C'|\{C_i\} \cup C' \cup C'') < 0$ .

The first part of the definition is common with our previous definition of equilibrium; all agents need to optimize and based on this, no intermediary makes negative profits. We also need to impose that these contracts are feasible, that is if a financial intermediary promises to undertake project  $j$ , it raises enough funds to do so. The second part is the 'reactive' equilibrium restriction. It requires that the existing contracts are optimal only against all deviations which themselves would not turn unprofitable.

**Proposition 6** (i)  $\forall S < S_h$  no (Perfect Bayesian) Equilibrium exists.

(ii)  $\forall S$ , the allocation characterized by Propositions 1 and 2 where all entrepreneurs exert effort is the unique Reactive Equilibrium.

The second part of this proposition is important for two reasons. First, it shows that there is a well-defined and unique equilibrium in our economy even with complex coalitions forming and functioning costlessly. Second, the unique equilibrium we have is always constrained inefficient because it leads to no experimentation, thus produces too little information.

## 4 Financial Institutions and Information.

We have so far established that (i) the amount of information increases with development, hence agency costs are lower in developed economies and (ii) the equilibrium of our economy, especially at the early stages of development, produces too little information. This second feature brings the question of what financial institutions may arise to deal with this inefficiency. The result in the previous subsection demonstrates that when access to information is not restricted, coalition formation will not

prevent the inefficiency. In this context we will argue that banks can be thought of as placing restrictions on access to information and/or producing information that cannot be easily transmitted.

Before we start it is useful to recall that we have also suggested that stock markets have good *information revelation and aggregation* properties. That is, the success of a project is observed publicly through the performance of its share on the stock market and this implies that the information contained in this performance regarding the underlying state is transmitted to all the agents in the economy. Yet, this informational advantage of stock markets creates a free-rider problem. No agent wants to bear the cost of experimenting [by choosing the low private return activity] to reveal information that is useful to the whole society. As a result, the advantage of stock markets in information aggregation makes them *disadvantageous* at information production. In the rest of the paper we will show that the market failure just discussed can explain the emergence of a specialized financial institution, which we will refer to as ‘banks’. We will emphasize two roles of banks [and for expositional reasons we will treat each separately though they are in no way exclusive]. *First*, banks are not as efficient at information aggregation as stock markets but this will make them well-suited to information production at the early stages by avoiding the free-rider problem. *Second*, banks have alternative ways of obtaining information, in particular as emphasized by Diamond (1984), they have the capacity to monitor individual effort choices.

The comparison of stock markets and banks is of considerable interest because empirically we observe that banks and other direct lending institutions played an important role in developing economies and stock and bond markets only emerged much later in the development process. For instance, in an important historical study, Goldsmith (1987) analyzes the financial structures of ten pre-modern societies and finds that banking was developed in a number of them while stock market type institutions were not observed at all except in Holland and there only due to special circumstances. However, since the nineteenth century stock markets have played an increasingly important role in the financing of new and existing ventures in many Western economies. Despite this well-known historical sequence, economic theory to date has offered no explanation<sup>9</sup>.

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<sup>9</sup>An exception is Greenwood and Smith (1993) who discuss debt versus equity and conclude that equity markets will never arise in equilibrium without government intervention. Another important contribution is Greenwood and Jovanovic (1990) who also motivate the existence of

## 4.1 Banks as ‘Experimenters’.

### 4.1.1 Equilibrium With Banks Only

In this subsection, we outline the first role of banks. The important distinction drawn in this section is between institutions that lend to a group of borrowers through a bilateral relation and institutional arrangements whereby each borrower comes into contact with the whole market. Banking will be modelled as an *exclusive* bilateral relation. That is, each bank enters into a relation with a number of entrepreneurs and provides all the funds to these entrepreneurs, and the information that is produced by these entrepreneurs is not observed by anyone other than the bank. Intuitively, if a company enters the stock market, the whole economy would observe its performance. In contrast, if it obtains all its finances from a bank, the economy will only have limited information on this company. We also assume that the functioning of banks is costly; if a bank runs  $\tilde{N}_b$  projects, there is a cost  $C_e(\tilde{N}_b)$  that is incurred in terms of final output in every state.  $C_e(\cdot)$  is positive, increasing and weakly convex. One possible justification for these costs comes from the fact that banks often gather information by making most of their investment in a particular industry and thus are not well-diversified. Also, banks in practice incur administrative costs which would be part of  $C_e(\cdot)$ . We now characterize the equilibrium of this economy when the only financial intermediation possibility is banking.

**Proposition 7** *Let  $C_e(\tilde{N}_b) = C_e \tilde{N}_b$ , then  $\forall C_e < \pi Z D^\beta$  such that:*

(i)  $\exists S_e(C_e)$  such that if  $S < S_e(C_e)$ , there is a unique equilibrium in which one bank is active and carries out experimentation in the form of  $\tilde{r} \geq 1$  entrepreneurs choosing low effort.

(ii) If  $S > S_e(C_e)$ , then we have a unique equilibrium without experimentation,  $\tilde{r} = 0$ .

**Corollary 1** *There exists an open set of strictly increasing and convex functions  $C_e(\cdot)$  such that in (i) and (ii) in Proposition 7, instead of a unique bank, we have a number  $l > 1$  of banks.*

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financial intermediaries by arguing that they run small scale experiments to extract information about the state of nature. However, since each intermediary finances a continuum of projects but only experiments on a countable subset of them, experimentation is a costless activity in their model, and there is no comparison of the information production roles of different financial institutions.

Since banks do not automatically reveal the information that is produced by the projects they are financing, they are subject to less severe free-rider problems. In particular, a bank in this economy is effectively on an isolated island; it does not receive outside information and there is no possibility of other banks free-riding on the information that it produces since this information is not publicly observed.

Note since in our model there is no source of uncertainty other than the underlying state of nature, if the aggregate performance of the bank were observed, the relevant information would again be perfectly revealed, thus the restrictions on information transmission introduced by banking could not work. However, this transmission would not occur easily if, as it seems plausible, other unobservable variables affect the performance of the bank. Further, we have left out of the analysis the possibility that banks trade in information. Although interesting, this extension would not alter the qualitative result as long as the costs of banking,  $C_e(\cdot)$ , are positive.

#### 4.1.2 Financial Development: Banks versus Stock Markets

When will intermediation be carried out through banks rather than stock markets? In answering this question, we restrict the analysis to the case in which banks have linear cost functions. The generalization of this result to the case of increasing marginal cost is straightforward. At this stage, a diagrammatic analysis will be most convenient. To write the utility of a saver in the stock market economy with aggregate saving level  $S < ND$ , we substitute  $K = D$  and  $n = \frac{S}{DN}$  in equation (7). Then we have the utility of a representative saver given by  $V(S) = \log(\zeta S)$  but with  $\zeta = \zeta_{nn} \equiv \frac{\pi Z D^{\beta-1}}{M + \frac{S}{D} \left[ E\left(\frac{B}{G^\pi}\right)^{(1-p)\frac{S}{DN}} - 1 \right]}$ .  $\zeta$  can be thought as the average rate of return on aggregate savings.

Instead of the decentralized equilibrium, now consider a hypothetical economy where *the underlying state is publicly observable*; we then have the same expression for the average rate of return on aggregate savings with  $\zeta = \zeta_{os} \equiv \frac{\pi Z D^{\beta-1}}{M + \frac{S}{D} \left[ E\left(\frac{B}{G^\pi}\right)^{(1-p)} - 1 \right]}$ . The difference is due to the fact that the true state becomes known with probability 1 rather than  $n$ . Finally, in another hypothetical world in which effort is *perfectly contractible*, we would have  $\zeta = \zeta_{ce} \equiv \frac{\pi Z D^{\beta-1}}{M + \frac{S}{D} [E-1]}$  since the entrepreneurs will only be paid their reservation return in the form of a constant salary.

Now let us turn to banking. When all projects are financed through banks,

the underlying state is inferred more precisely since the banks will carry out experimentation. On the other hand, banking comes at the cost of  $C_e$  per project. Therefore, the average rate of return on savings would be given by  $\zeta = \zeta_{be} \equiv \frac{\pi Z D^{\beta-1} - C_e \frac{S}{D}}{M + \frac{S}{D} \left[ E \left( \frac{B}{G\pi} \right)^{(1-p\rho')} - 1 \right]}$  where  $\rho'$  is the probability that the *Good* state is revealed.  $\rho'$  depends on the optimal extent of experimentation and  $n \leq \rho' < 1$  when less than  $N$  projects can be opened. Figure 1a plots the inverse of these four rates of return (plotting the inverse simplifies the diagrams). As before, the equilibrium will maximize the utility of a representative saver taking the decision of all other savers as given [but of course no experimentation is possible with stock markets].

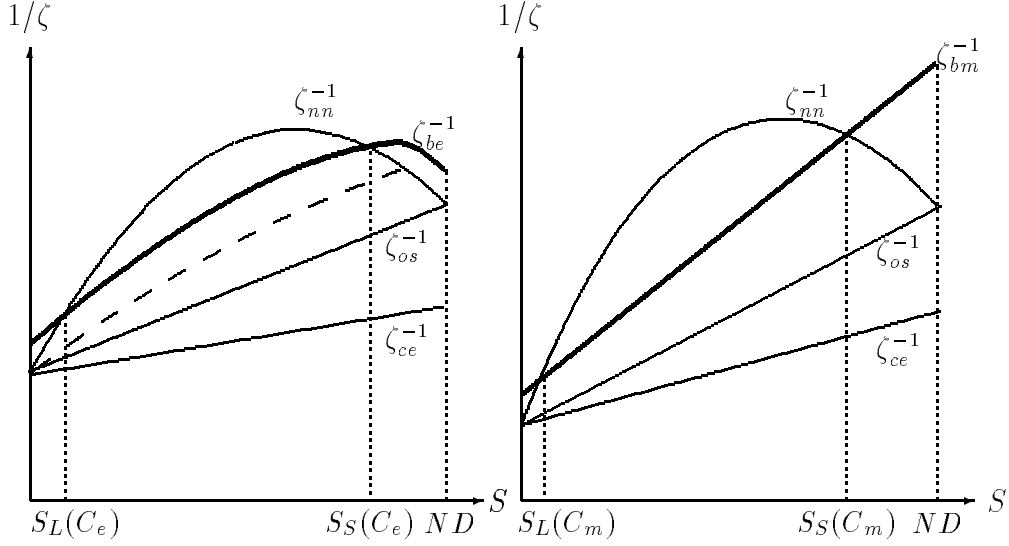


Figure 1a. Banks as ‘experimenters’. Figure 1b. Bank as ‘monitors’.

$\zeta_{ce}^{-1}$  lies below the other curves, implying that the rate of return with contractible effort is highest.  $\zeta_{os}^{-1}$  starts at the same point but lies everywhere above  $\zeta_{ce}^{-1}$  [the intuitive reason why these curves start at the same point is that when savings are zero, the utility of consumption is minus infinity and the cost of effort does not matter relative to this].  $\zeta_{nn}^{-1}$  also starts at the same point, but because the underlying state is not observed, it is above  $\zeta_{os}^{-1}$  until aggregate savings reach  $ND$ . At this point, all projects are run with high effort and the underlying state of nature is revealed almost surely, thus the two curves meet again. Next to understand the shape of  $\zeta_{be}^{-1}$  (thicker curve), suppose that banks function at no cost (i.e.  $C_e = 0$ ), then the (inverse of the) rate of return is given by the dashed curve which is also the Constrained Pareto Optimum of this economy. This line starts at the same point

as the other curves, then it remains below  $\zeta_{nn}^{-1}$  [because the agency contracts in this case can use more information than the decentralized economy], and then finally, at the point where the bank finds it optimal to stop experimentation, it meets  $\zeta_{nn}^{-1}$ . As the cost of banking  $C_e$  increases,  $\zeta_{be}^{-1}$  shifts up multiplicatively. Inspection of this Figure is sufficient to establish the following proposition [except for the multiplicity aspect which is discussed below].

**Proposition 8**  $\exists \hat{C}_e, S_L(C_e), S_S(C_e)$  such that for  $C_e < \hat{C}_e$ ;

(i) If  $S \in (S_L(C_e), S_S(C_e))$ , then  $\zeta_{be} > \zeta_{nn}$  and in equilibrium all funds are intermediated by banks.

(ii) If  $S > S_S(C_e)$ , then  $\zeta_{be} \leq \zeta_{nn}$ , and in the absence of investment funds in the stock market, there exist multiple equilibria; one with banking and one with stock market intermediation. With investment funds, the only (Reactive) equilibrium has all savings intermediated through the stock market.

Returning to Figure 1a, if  $C_e$  is not too large, there will be a range of saving levels such that banking is the only equilibrium. Instead, when  $S > S_S(C_e)$  banking is less efficient than the stock market. If coalitions among entrepreneurs can be formed costlessly (say, through financial intermediaries), stock market will be the unique equilibrium. However, if we do not allow costless coalitions, there also exists an equilibrium with banks. Intuitively, if no firm enters the stock market, then there is no information in the economy regarding the underlying state of nature and agency costs would be very high for a project that uses the stock market.

The predictions of our model are consistent with the pattern which is typically observed in the development experience of many countries. Developed economies use institutions such as stock and bond markets quite widely whereas less developed economies exclusively rely on banks and bilateral direct lending relations [see Goldsmith, 1987]. The intuition for why there is this historical switch between the two types of institutions is worth discussing. As noted above, banks actively produce information but are inefficient at information aggregation. In more developed economies the amount of information that needs to be aggregated is larger (that is,  $\tilde{N}$  is higher) and since there is information available at no cost, the need for active experimentation diminishes. As an economy grows rich, information production becomes less important and information aggregation, the activity at which stock markets have a comparative advantage, gains importance, hence the switch from

banks to stock markets<sup>10</sup>. In support of this thesis, we can quote Goldsmith on the stock market of Holland “*the exchange’s price list... was one of the most important sources of information for the period’s international trade.*” [p. 217, see also North and Thomas, 1973 for statements to the same effect]. This suggests that, as we argue in this paper, even the first proper stock market of economic history appears to have acted as an important source of information.

Therefore, our model explains the late emergence of stock markets by the different comparative advantages of various financial institutions in producing information. Naturally, the prediction that once the stock market is introduced banks disappear is unrealistic, but it is due to the simplicity of our framework in which banks only perform ‘experimentation’ activity, as well as our assumption that all projects are homogenous.

## 4.2 Banks as Monitors

The other role of banks is to reduce transaction and agency costs via monitoring. Assume that each project can be *interim* monitored at the some constant cost, which we denote as  $C_m$ . Monitoring enables the bank to observe whether the entrepreneur exerts effort or not. Therefore, monitoring forces high effort. For simplicity, we also assume that these banks necessarily monitor all projects. More realistic specifications in which banks can decide to randomly monitor some projects, or to ex-post monitor only unsuccessful projects [as in Diamond, 1984] would give the same results.

Since each bank deals with a large number of projects, it can provide perfect insurance to the entrepreneur and pay him a flat wage  $[\bar{\omega}$  as defined in Proposition 3] so as to meet his participation constraint. Thus we can write the return from

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<sup>10</sup>Note that the model also predicts that at the very primitive stages of development (for  $S < S_L(C_e)$ ), the stock market performs better than banking. This is because stock markets are supposed to function at no administrative cost which is an unrealistic assumption but makes the rest of our mechanism easier to appreciate. Goldsmith (1987)’s analysis of pre-modern financial systems shows that at the very early stages, there was no intermediation, and it was only after a number of necessary economic conditions were met that banks started to play an important role in financial intermediation. Therefore, the historical pattern suggests a sequence of a period of almost no intermediation, then banking and then finally a period of stock market intermediation. In Acemoglu and Zilibotti (1996a), we show that when we allow for an alternative technology without division of labor and no need of financial contracts this technology will be chosen at the very early stages of development. Therefore combining the results of these two papers, we have predictions which are in line with the stylized fact about financial development.

banking in this case as  $\zeta = \zeta_{bm} \equiv \frac{\pi Z D^\beta - C_m \frac{S}{D}}{M + \frac{S}{D}[E-1]}$ . This time for  $C_m = 0$ , the curve  $\zeta_{bm}^{-1}$  is the same as  $\zeta_{ce}^{-1}$  in Figure 1b, and for  $C_m > 0$ , it shifts up multiplicatively. Therefore, as long as  $C_m$  is less than a critical value  $\hat{C}_m$ , the curve  $\zeta_{bm}^{-1}$  will be below  $\zeta_{nn}^{-1}$  over some range. But also if monitoring is very cheap, stock markets will never be preferred, thus  $C_m$  needs to be greater than another critical value  $\bar{C}_m$  and in this case Proposition 8 will apply to monitoring banks exactly as to banks as experimenters. The sequence of financial institutions that arise in equilibrium will again be in line with the historical pattern. Intuitively, heavy reliance on direct monitoring is costly and is only necessary when other methods of providing incentives to entrepreneurs do not work. In rich economies more information is revealed, and it is optimal to rely on the stock market to aggregate this information rather than make heavy use of direct monitoring. It is also interesting to observe that the conclusion that monitoring should play a less important role in modern society than in more ancient societies is in line with the view that information has become more decentralized and privacy has acquired a value it did not have before.

## 5 Concluding Comments

Agency costs feature importantly in many accounts of the process of development. High risk-premia, distorted incentives, corruption, limitations on the division of labor can all be related to the high agency costs faced by less developed economies. Why are agency costs high? We suggest an answer to this question based on the idea that the limited range of projects undertaken in less developed economies leads to relatively less information for the society to be used in devising the right incentives for agents. This argument explains a number of stylized facts about development of financial institutions and evolution of incentive contracts.

The mechanism proposed in this paper opens a number of avenues for future research. If indeed information reduces agency costs and is increasing in the amount of savings, similar arguments can be applied to understand the emergence of organizations that rely on more complex divisions of labor and deeper hierarchies. Furthermore, we have omitted in this paper the importance of income distribution on financial arrangements and agency costs. The interaction between these two aspects has not yet been investigated but potentially important in understanding both the development of financial institutions and the incentive problems faced by many societies today.

# APPENDIX: Proofs

## Proof of Proposition 1.

1. Suppose that (4) holds with strict inequality for the entrepreneur running project  $v$ . The objective function could be increased by reducing the entrepreneur's salary in all states. Next consider the case where (5) holds with strict inequality. Then a mean-preserving contraction in  $\omega_1^v$  and  $\omega_0^v$  would still satisfy the incentive compatibility constraint but would increase the utility of the entrepreneur, thus  $\tilde{\omega}_1^v$  and  $\tilde{\omega}_0^v$  can be reduced without violating the participation constraint and hence the objective function would be increased [note that due to log utility, we can always reduce these salaries without hitting a boundary].  $\square$
2. Let  $B$  and  $G$  be as in the Proposition,  $\omega_1 = G\omega_0$  follows from (5) and Part 1 of this Proposition. Then by substituting from (5) into (3) and (4), the maximization problem can be written as:

$$V(n, K) = \max_{\omega_0, \tilde{\omega}_1, \tilde{\omega}_0} (1 - pn) \log(\pi Z K^\beta - B\omega_0) + pn \log \left[ (\pi Z K^\beta - \pi \tilde{\omega}_1 - (1 - \pi) \tilde{\omega}_0) \right] + \log \left( \frac{n}{m - n} \right) \quad (\text{A.1})$$

subject to:

$$(1 - pn)[\pi \log G + \log \omega] + pn[\pi \log \tilde{\omega}_1 + (1 - \pi) \log \tilde{\omega}_0] - e = V(n, K) \quad (\text{A.2})$$

The conditions that  $\tilde{\omega}_0 = \tilde{\omega}_1 = B\omega_0$  (part 1 of the Proposition) are immediate from the F.O.C's with respect to  $\omega_0$ ,  $\tilde{\omega}_0$  and  $\tilde{\omega}_1$  (we omit the details). Then, the objective function can be written (eq. (A.1)) as:

$$V(n, K) = \max_{\omega_0} \log \left[ \pi Z K^\beta - B\omega_0 \right] + \log \left( \frac{n}{m - n} \right) \quad (\text{A.3})$$

and the participation constraint (A.2) as:

$$\log(B\omega_0) - (1 - pn)[\log B - \pi \log G] = V(n, K) + e \quad (\text{A.4})$$

(A.3) and (A.4) uniquely determine the solution for  $V(n, K)$  and  $\omega_0$  which is given by expressions (6) and (7) in the text.  $\square$

3. Substituting  $\omega_0$  into (A.3) proves 3.
4. The first part follows from the previous point. The calculation of the partial derivatives is straightforward.  $\square$

**Proof of Proposition 2.** *First part.* Suppose  $A(M - N) \leq ND$ , so not all projects can be opened. We will first maximize (7) with respect to  $n$  and  $K$  subject to the resource

constraint ( $nK \leq \frac{S}{N}$ ) and the minimum size constraint ( $K \geq D$ ). Then, we will determine the equilibrium value of  $n$  and  $S$ . Since  $V_n > 0, V_K > 0$  (see Proposition 1) the resource constraint must be binding. By using the resource constraint to eliminate  $K$ , we can then rewrite (7) as:

$$V(n) = \log \left( \pi Z \left( \frac{S}{N} \right)^\beta \right) + (1 - \beta) \log(n) - \log \left[ m + n \left( E \left( \frac{B}{G^\pi} \right)^{(1-pn)} - 1 \right) \right]. \quad (\text{A.5})$$

This expression is to be maximized with respect to  $n$  subject to the (minimum size) constraint that  $n \leq \frac{S}{ND}$ . The first order condition is:

$$\frac{1 - \beta}{n} - \frac{E \left( \frac{B}{G^\pi} \right)^{(1-pn)} - 1 - E \left( \frac{B}{G^\pi} \right)^{(1-pn)} p \log \left( \frac{B}{G^\pi} \right)}{m + n \left[ E \left( \frac{B}{G^\pi} \right)^{(1-pn)} - 1 \right]} - \mu = 0 \quad (\text{A.6})$$

where  $\mu \geq 0$  is the Lagrangean multiplier of the minimum size constraint. A sufficient condition for  $\mu$  to be strictly positive is that:

$$\frac{1 - \beta}{n} > \frac{E \left( \frac{B}{G^\pi} \right)^{(1-pn)} - 1}{m + n \left[ E \left( \frac{B}{G^\pi} \right)^{(1-pn)} - 1 \right]} \quad (\text{A.7})$$

which is equivalent to:

$$\frac{1 - \beta}{\beta} m > n \left[ E \left( \frac{B}{G^\pi} \right)^{(1-pn)} - 1 \right] \quad (\text{A.8})$$

Finally,

$$\forall n \in (0, 1), \quad n \left[ E \left( \frac{B}{G^\pi} \right)^{(1-pn)} - 1 \right] < \left[ E \left( \frac{B}{G^\pi} \right) - 1 \right] \quad (\text{A.9})$$

Therefore, Assumption 1 is sufficient to ensure that  $K = D$ . Next, since  $\tilde{N}D = S$  (resource constraint) and  $A(M - \tilde{N}) = S$  (savings equal wage income), we obtain that  $S = \frac{A}{A+D}DM$  and  $\tilde{N} = \frac{S}{D}$ , and the first part of the Proposition is proved.

*Second part.* If  $A(M - N) \geq ND$ , the *first part* implies that the economy will open as many projects as possible, thus  $n = 1$ . Then, from the fact that  $V_K(1, K) > 0$ , it follows that the resource constraint will be binding, so  $NK = S$ . Finally, a maximum of  $N$  agents can become entrepreneurs, hence  $A(M - N) = W = S$ . This completes the proof.  $\square$

**Proof of Proposition 3.** First, consider the case in which effort were contractible. Then the salary of the entrepreneur would be independent of  $n$  and thus of the amount of savings, which implies

$$\bar{V}(n, K) = \log(\pi Z K^\beta - \bar{\omega}) + \log \frac{n}{m - n} \quad (\text{A.10})$$

and

$$\log \bar{\omega} = \bar{V}(n, K) + e \quad (\text{A.11})$$

where (A.11) is the relevant participation constraint. Hence:

$$\bar{\omega} = \frac{E \frac{n}{m-n}}{1 + E \frac{n}{m-n}} \pi Z K^\beta \quad (\text{A.12})$$

From equation (6) we know that:

$$B\omega_0 = \frac{E \left( \frac{B}{G^\pi} \right)^{(1-pn)} \frac{n}{m-n}}{1 + E \left( \frac{B}{G^\pi} \right)^{(1-pn)} \frac{n}{m-n}} \pi Z K^\beta \quad (\text{A.13})$$

Then agency costs are given by:

$$\frac{B\omega_0}{\bar{\omega}} = \frac{1 + E \frac{n}{m-n}}{\left[ \left( \frac{B}{G^\pi} \right)^{(1-pn)} \right]^{-1} + E \frac{n}{m-n}} \quad (\text{A.14})$$

which is decreasing with  $n$ , as it can be verified by differentiation.  $\square$

**Proof of Lemma 1.** Since the probability of discovering the *Good* state is  $\rho$ , the program to be solved becomes:

$$\begin{aligned} \max V(n, K) = & [p(1 - \rho) + (1 - p)] \log \left[ \left( \frac{n}{m - n} \right) (\pi Z K^\beta - \pi \omega_1 - (1 - \pi) \omega_0) \right] + \\ & + p\rho \log \left[ \left( \frac{n}{m - n} \right) (\pi Z K^\beta - \pi \tilde{\omega}_1 - (1 - \pi) \tilde{\omega}_0) \right] \end{aligned} \quad (\text{A.15})$$

subject to the constraints

$$(1 - \rho)[\pi \log \omega_1 - (1 - \pi) \log \omega_0] + p\rho[\pi \log \tilde{\omega}_1 - (1 - \pi) \log \tilde{\omega}_0] - e \geq V(n, K) \quad (\text{A.16})$$

$$(1 - p)\pi(\log \omega_1 - \log \omega_0) \geq e \quad (\text{A.17})$$

The first order conditions of the problem, as in Proposition (1), yield  $\omega_1 = G\omega_0$  and  $\tilde{\omega} = B\omega_0$  whatever the probability of discovering the underlying state,  $\rho$ . Following the steps above, we can solve:

$$V(n, K|\rho) = \log(\pi Z K^\beta) - \log \left( \frac{m}{n} + E \left( \frac{B}{G^\pi} \right)^{(1-p\rho)} - 1 \right) \quad (\text{A.18})$$

$$b(n, K|\rho) = \left\{ \frac{(\pi Z K^\beta)}{\left( \frac{m}{n} + E \left( \frac{B}{G^\pi} \right)^{(1-p\rho)} - 1 \right)} \right\} \quad (\text{A.19})$$

Straightforward differentiation shows that both expressions are increasing in  $\rho$  everywhere.  $\square$

**Proof of Lemma 2.** We characterize the minimum cost of entrepreneurship when some entrepreneurs choose low effort. To start with, note that when some projects are with

low effort, the economy can be subject to aggregate uncertainty since in the *Bad* state, all of the low effort projects fail. In this proof, we will ignore the cost induced by the introduction of uninsurable risk, since this risk would make low effort less desirable and thus make our argument true *a fortiori*. Ignoring the uninsurable risk implies that the entrepreneurs who are induced to exert no effort are offered a flat wage, which we denote by  $\omega^{le}$ .

The participation constraint for the no effort entrepreneur implies  $\log(\omega^{le}) = V(n, K)$ . On the other hand, the participation and incentive constraints for the rest of the entrepreneurs (4) and (5) together with the first part of Proposition 1 give  $\log(B\omega_0) = \log\left(\frac{B}{G^\pi}\right)^{(1-p\rho)} + e + V(n, K)$ . The two conditions together yield:

$$\omega^{le} = \frac{B\omega_0}{E\left(\frac{B}{G^\pi}\right)^{(1-p\rho)}} \quad (\text{A.20})$$

Then:

$$\begin{aligned} b(n, K|\rho) - b^{le}(n, K|\rho) &= \left[ (\pi Z K^\beta - B\omega_0) - \left( p\pi Z K^\beta - \frac{B\omega_0}{E\left(\frac{B}{G^\pi}\right)^{(1-p\rho)}} \right) \right] = \\ &\pi Z K^\beta \left[ (1-p) - \left( 1 - \frac{1}{E\left(\frac{B}{G^\pi}\right)^{(1-p\rho)}} \right) \frac{B\omega_0}{\pi Z K^\beta} \right] \end{aligned} \quad (\text{A.21})$$

The RHS of (A.23) reaches a minimum at  $\tilde{N} = N$  [since the only term which depends on  $\tilde{N}$ , i.e.  $\frac{B\omega_0}{\pi Z K^\beta}$ , is at its maximum at  $N = \tilde{N}$  — see the expression for  $B\omega_0$  in the proof of Proposition 1]. At the minimum, the RHS of (A.21) becomes:

$$\frac{\pi Z K^\beta}{1 + \frac{N}{M-N} E\left(\frac{B}{G^\pi}\right)^{(1-p\rho)}} \left[ 1 + \frac{N}{M-N} - p \left( 1 + \frac{N}{M-N} E\left(\frac{B}{G^\pi}\right)^{(1-p\rho)} \right) \right] \quad (\text{A.22})$$

and some simple algebra using the definition of  $E$ ,  $G$  and  $B$  shows that the term within brackets is always positive as long as Assumption 2 is satisfied.  $\square$

**Proof of Proposition 4.** Consider, first, an allocation such that  $N_d < \frac{S}{D}$  agents are entrepreneurs. Then there is an opportunity for a  $N_d + 1^{st}$  agent to become an entrepreneur and increase his expected utility since there are enough funds. Therefore, any equilibrium allocation must have  $\tilde{N} = \frac{S}{D}$  entrepreneurs. Consider now an allocation where  $r > 0$  of the  $\tilde{N}$  entrepreneurs raise funds with a flat wage contract at  $\omega^{le}$ . Savers will naturally anticipate that they will exert no effort. By Lemma 2, the contribution of each low effort project to the savers' portfolio is lower than that guaranteed by high effort projects. So, each low effort project will raise less funds than  $D$  and will not be feasible. Therefore in equilibrium we cannot have  $r > 0$ . Finally, consider the case in which  $\tilde{N}$  entrepreneurs offer contracts that satisfy the incentive compatibility constraint and thus savers anticipate high effort. Now, if a  $\tilde{N} + 1^{st}$  agent decides to become entrepreneur, he will not be able to raise enough funds with either a high effort or low effort contract. Further none of the

entrepreneurs can improve on this allocation, therefore the allocation with  $\tilde{N}$  high effort contract is an equilibrium and there cannot be any other.  $\square$

**Proof of Proposition 5.** Consider as a benchmark the allocation in which effort is induced for all projects ( $r = 0$ ). Now suppose that for a small number of entrepreneurs  $r$  we replace the incentive compatible contract with a flat wage  $\omega^{le}$ . Let  $\rho, \rho'$  be respectively the probabilities of discovering the *Good* state before and after the contract replacements. To be precise, we have  $\rho = \frac{\tilde{N}}{N}$  and  $\rho' = \frac{\tilde{N}-r}{\tilde{N}} + \left(1 - \frac{\tilde{N}-r}{\tilde{N}}\right) [1 - (1 - \pi)^r]$ . So,  $\rho' = \rho + [1 - (1 - \pi)^r] (1 - \frac{\tilde{N}}{N}) + \frac{r}{N} (1 - \pi)^r$ .

This increase in probability of discovering the underlying state from  $\rho$  to  $\rho'$  will cause a change in the expected return equal to:

$$(\tilde{N} - r) [b(n, K|\rho') - b(n, K|\rho)] - r [b(n, K|\rho) - b^{le}(n, K|\rho')] \quad (\text{A.23})$$

where the first term is the effect of the increase in the information which the remaining  $(\tilde{N} - r)$  incentive contracts can be conditioned upon, and the second term is the loss return from inducing no effort in  $r$  firms. (A.23) can be written as:

$$\tilde{N} [b(n, K|\rho') - b(n, K|\rho)] - r [b(n, K|\rho') - b^{le}(n, K|\rho')] \quad (\text{A.24})$$

where the first term is positive and the second is negative by Lemmas 1 and 2, respectively. We now proceed in two steps. First, we show that when a non-negligible fraction of projects are not open, i.e. when  $h \equiv N - \tilde{N}$  has the same order of magnitude as  $N$  [that is  $\frac{h}{N} > 0$ ], then experimentation is always desirable. Second, we analyze the case in which  $h$  is small (infinitesimal) with respect to  $N$  so that  $n \rightarrow 1^-$  [that is  $\frac{h}{N} \approx 0$ ]. In the first case, since  $N$  is by assumption ‘large’, then  $\rho' \simeq \rho + \pi(1 - n)$  [note that since  $(1 - n) = \frac{h}{N}$ , the assumption that  $h$  is not infinitesimal with respect to  $N$  is crucial for this approximation]. Then, since  $b(n, K|\rho') - b(n, K|\rho) > 0$ , there exists  $r > 0$ , small relative to  $\tilde{N}$ , such that (A.24) is strictly positive.

Next, consider the case of ‘small’  $h$ , namely the limiting case in which  $n \rightarrow 1^-$ . Now, the previous argument does not apply because  $b(n, K|\rho') - b(n, K|\rho)$  becomes infinitesimal. In this case, we need to write the explicit expression for the benefit of experimentation, namely:

$$\tilde{N} [b(n, K|\rho') - b(n, K|\rho)] = \frac{\tilde{N}}{N} \pi Z K^\beta N \left\{ \frac{1}{1 + \frac{n}{m-n} E \left( \frac{B}{G^\pi} \right)^{(1-p\rho')}} - \frac{1}{1 + \frac{n}{m-n} E \left( \frac{B}{G^\pi} \right)^{(1-p\rho)}} \right\} \quad (\text{A.25})$$

which, after rearranging, gives:

$$\frac{\pi Z K^\beta \frac{n^2}{m-n} E \left( \frac{B}{G^\pi} \right)^{(1-p)}}{\left( 1 + \frac{n}{m-n} E \left( \frac{B}{G^\pi} \right)^{(1-p\rho')} \right) \left( 1 + \frac{n}{m-n} E \left( \frac{B}{G^\pi} \right)^{(1-p\rho)} \right)} \left[ \frac{\left( \frac{B}{G^\pi} \right)^{\frac{ph}{N}} - \left( \frac{B}{G^\pi} \right)^{\frac{p(1-\pi)^r(h+r)}{N}}}{1/N} \right] \quad (\text{A.26})$$

We can now take the limit of this expression as  $N \rightarrow \infty$  and  $n \rightarrow 1^-$ . Note that to calculate the limit of the second term (which is of the type  $\frac{0}{0}$ ) we use L'Hôpital Rule. The resulting expression is:

$$\lim_{N \rightarrow \infty, n \rightarrow 1^-} N [b(n, K|\rho') - b(n, K|\rho)] =$$

$$\pi Z K^\beta \frac{E \left( \frac{B}{G^\pi} \right)^{(1-p)} \frac{N}{M-N}}{\left[ 1 + E \left( \frac{B}{G^\pi} \right)^{(1-p)} \frac{N}{M-N} \right]^2} p \log \left( \frac{B}{G^\pi} \right) [h - (1 - \pi)^r (h + r)] \equiv Q[h - (1 - \pi)^r (h + r)] \quad (\text{A.27})$$

which is a positive function of  $h$  [where the expression  $Q$  is defined for future use].

Next, consider the cost. We have:

$$\lim_{N \rightarrow \infty, n \rightarrow 1^-} r [b(n, K|\rho') - b^{le}(n, K|\rho')] =$$

$$r \pi Z K^\beta \left[ (1 - p) - \frac{1 - \frac{1}{E \left( \frac{B}{G^\pi} \right)^{1-p}}}{1 + \frac{N}{M-N} E \left( \frac{B}{G^\pi} \right)^{1-p}} \right] \equiv r H \quad (\text{A.28})$$

The net value of experimentation – which depends on  $r$  as well as on  $h$  – is

$$Q[h - (1 - \pi)^r (h + r)] - r H \quad (\text{A.29})$$

and, for given  $h$ , experimentation is beneficial iff  $\exists r \in N^+$ , such that this expression is positive. For  $r = 0$ , this (A.29) is equal to zero and for  $r \neq 0$  it can be written as:

$$h > T(r) \equiv r \frac{H/Q + (1 - \pi)^r}{1 - (1 - \pi)^r} \quad (\text{A.30})$$

Equation (A.23) gives:

$$S_h = N - \min_{r \in N^+} T(r) \quad (\text{A.31})$$

where  $S_h$  is the critical savings level such that such that  $\forall S < S_h$  experimenting is optimal. Finally, since  $S_h < ND$ , we immediately obtain that  $S \geq S_h$  experimenting has higher cost than benefit, therefore, in this range  $r = 0$  as claimed. This completes the proof.  $\square$

**Proof of Proposition 6. Part (i).** First, we will show that there will exist a contract that makes positive profits if the allocation has positive amount of experimentation [*Result 1*]. Then, we will prove that for  $S < S_h$ , there exists a contract that will make positive profit when the allocation in question has no experimentation [*Result 2*]. These two results will prove that there exists no equilibrium with our previous equilibrium concept. Then we will move to prove the existence of a unique Reactive Equilibrium.

*Result 1.* Experimentation means that a financial intermediary that markets a set of projects  $U^*$  is inducing a subset of this  $u^{**} \subset U^*$  to exert no effort – that is,  $r \geq 1$  entrepreneurs are offered a flat wage  $\omega^{le}$ . Let us also denote the probability of discovering that the underlying state was *Good* by  $\rho$  as before. By Lemma 2, the return on these  $r$  projects,  $b^{le}(n, K|\rho)$ , is lower than the return on the other  $\tilde{N} - r$  projects  $b(n, K|\rho)$ .

Now, another intermediary can attract all entrepreneurs in the set  $U^* \setminus u^{**}$  by offering them a slightly higher reward in all states, and market this security to savers at rate of return  $b(n, K|\rho) - \epsilon$ , who will prefer this new security for  $\epsilon$  small enough; as long as  $u^{**} \neq \emptyset$ , this deviant intermediary would make positive profits. Thus no allocation with experimentation can be an equilibrium.  $\square$

*Result 2.* Consider an allocation where a subset of projects  $U^* \subset U = [0, N]$  is open and all entrepreneurs exert effort. Now another intermediary can enter, attract all the entrepreneurs in the set  $U^*$  by offering all but one of them a slightly higher reward in all states, and the remaining one a flat wage ( $\omega^{le} + \epsilon$ ), where  $\omega^{le}$  is defined by (A.22). By the first part of Proposition 5 this portfolio gives higher utility to all savers and thus the coalition can make positive profits.  $\square$

**Part (ii).** We will first show that the high effort allocation is an equilibrium [Result 3] and then that no others exist [Result 4]. We focus on  $S < S_h$ , which is the region where an equilibrium did not exist. For the other cases an equilibrium exists with our previous equilibrium concept and is the high effort equilibrium. Let  $\rho = n$  be the information available in the absence of experimentation, and  $\rho' > \rho$  the information available when some experimentation is carried out (see the proof of Proposition 5 for details). Also, remember from Proposition 1 that savers bear no risk, thus we can work with average rates of returns without worrying about variability of returns.

*Result 3* Consider the candidate equilibrium allocation where a number  $L$  of intermediaries offer identical incentive compatible contracts of the type described by Proposition 1. Now, if we call  $C_i$  this set of contracts, [Result 2] above shows that  $\exists C' | \Pi(C' | \{C_i\} \cup C') > 0$ . However, as shown by [Result 1], for such  $C'$  there also exists  $C''$  such that a second round of entry is profitable, i.e.  $\Pi(C'' | \{C_i\} \cup C' \cup C'') > 0$ . Then, to show that the candidate is a Reactive Equilibrium we only have to show that  $\Pi(C' | \{C_i\} \cup C' \cup C'') < 0$ .

As it is characterized in the proof of [Result 1],  $C''$  steals all projects that had high effort, and leaves projects that have no effort with the incumbent intermediary that offered  $C'$ . The average rate of return when there is experimentation to a small number of projects is  $b(n, K|\rho')$ . Therefore,  $C''$  provides savers with a return up to  $b(n, K|\rho')$ . But, by Lemma 2,  $b(n, K|\rho') > b^{le}(n, K|\rho')$ . Furthermore, in order to attract savers away from  $\{C_i\}$ ,  $C'$  must have offered at least the return from high effort that is  $b(n, K|\rho)$ , where, again by Lemma 2,  $b(n, K|\rho) > b^{le}(n, K|\rho)$ . Now we claim (postponing by few lines the proof) that  $b^{le}(n, K|\rho') < b^{le}(n, K|\rho)$ . This implies that the intermediary which had entered at the first stage offering  $C'$  is left only with the no effort projects and therefore making a loss, because it is offering savers a return  $b(n, K|\rho)$ . This establishes that all entrepreneurs exerting effort is an equilibrium.

To finish the proof of *Result 3*, we need to show that, as claimed above,  $b^{le}(n, K|\rho') < b^{le}(n, K|\rho)$ . To see this, observe that:  $b^{le}(n, K|\rho') = (p\pi ZK^\beta - \omega^{le})$  is decreasing with  $\rho$  since:  $\omega^{le} = \frac{B\omega_0}{E(\frac{B}{G\pi})^{(1-\rho n)}} = \frac{\frac{m}{m-n}\pi ZK^\beta}{1+E(\frac{B}{G\pi})^{(1-\rho n)}\frac{m}{m-n}}$  is increasing with  $\rho$ .

*Result 4.* We now show that no other equilibrium exists. Consider an allocation in which some projects choose low effort (set  $u_l / g = \emptyset$ ). If we can show that no such allocation can be an equilibrium, we will have established the uniqueness of the high effort equilibrium. First, by the above argument (i.e. that  $b(n, K|\rho) > b^{le}(n, K|\rho')$ ), the low effort projects must be run by an intermediary who also runs a number of high effort projects - let us call the set of these projects with high effort  $u_h$ . But as long as  $u_h \neq \emptyset$ , there exists another intermediary who can offer  $C'$  and attract all these projects in  $u_h$ . And this intermediary can offer a rate of return as high as  $b(n, K|\rho')$  because the experimentation of the first intermediary who offered  $C$  still reveals the underlying

state with probability  $\rho'$ . Thus this new intermediary with  $C'$  can make positive profits. Therefore, to show that this candidate allocation is not an equilibrium it is sufficient to show that for any further entry  $C''$ ,  $C'$  would *not* make negative profits, that is  $\Pi(C'|\{C_i\} \cup C' \cup C'') \geq 0$ . However, this is true by definition since  $C'$  does not do cross-subsidization of projects; the worst that can happen is that it loses  $u_h$  because  $C''$  offers a better return (say closer to the maximum rate  $b(n, K|\rho')$ ), but  $C'$  never makes negative profits.  $\square$

**Proof of Proposition 7.** First, the condition that  $C_e < \pi Z D^\beta$  ensures that the return to each project remains positive after paying the banking cost. Second, free entry implies that if a unique bank is active, it will implement the Constrained Social Optimum subject to payment of the ‘administrative’ cost of  $C_e$  per project. Note that no entrant can free-ride on the experimentation carried out by the incumbent bank because the resulting information does not become public. Finally, the proof that experimentation will be adopted if and only if the stock of savings is below some threshold ( $S_e$ ) follows the proof of Proposition 5 except for the cost  $C_e$  which needs to be subtracted from the return of each project. The corresponding expression is:

$$S_e(C_e) = \min_{r \in N^+} \equiv r \frac{H/\tilde{Q}(C_e) + (1-\pi)^r}{1 - (1-\pi)^r} \quad (\text{A.32})$$

where

$$\tilde{Q} \equiv (\pi Z K^\beta - C_e) \frac{E\left(\frac{B}{G^\pi}\right)^{(1-p)} \frac{N}{M-N}}{\left[1 + E\left(\frac{B}{G^\pi}\right)^{1-p} \frac{N}{M-N}\right]^2} p \log\left(\frac{B}{G^\pi}\right)$$

This completes the proof of the Proposition.  $\square$

**Proof of Corollary 1:** First note that as long as  $C_e(1) < \pi Z K^\beta$ , there exists an equilibrium with banking. This follows immediately from the fact that the allocation in which each project is run by one bank dominates no production. Second, note that in all equilibria, banks have to make zero profits; otherwise, another bank could enter and run exactly the same projects and pay  $\epsilon$  more to the savers in all states. Now we will construct an example where  $C_e(\cdot)$  is increasing and convex and where there are a number of banks larger than 1 carrying out active experimentation. Let the savings level be  $S < S_h$ , then consider the following cost function for banks:

$$C_e^\infty(\tilde{N}_b) = \begin{cases} C_e \tilde{N}_b & \text{if } \tilde{N}_b \leq N_b \\ \bar{C}_e \tilde{N}_b & \text{if } \tilde{N}_b > N_b \end{cases} \quad (\text{A.33})$$

where  $N_b < \frac{S}{2D}$  and  $\frac{N_b}{N} > 0$ . Also  $C_e < \pi Z D^\beta$  and  $\bar{C}_e > C_e$ . Let  $\bar{C}_e \rightarrow \infty$ , then we will have at least two banks in this economy. Next, since at least two banks will have  $N_b$  projects and  $\frac{N_b}{N} > 0$ , experimentation is profitable by the argument of the proof of Proposition 5. This establishes that for  $C_e^\infty(\cdot)$  increasing and convex, we have an equilibrium with many banks and each bank (with the possible exception of one that may be too small) runs active experimentation. Next, suppose a sequence of increasing convex functions,  $\{C_e^k(\cdot)\}_k \rightarrow C_e^\infty(\cdot)$ , and a sequence of economies  $\{E^k\}_k$  such that economy  $k$  has the

banking cost function  $C_e^k$ . Then it immediately follows that  $\exists k^*$  such that  $\forall k \geq k^*$ , the equilibrium of economy  $E^k$  has a number  $l^k > 1$  of banks where each bank (but possibly one) runs experimentation with  $r^k > 0$ .  $\square$

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