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PUBLIC INPUTS AND THE CREDIT MARKET

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PUBLIC INPUTS AND THE CREDIT MARKET

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ABSTRACT

PUBLIC INPUTS AND THE CREDIT MARKET

By

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Public inputs like infrastructure used collectively by firms also contribute towards reducing the heterogeneity among firms in an economy. This has important implications for allocations in the credit markets, which are besieged by information asymmetries among such firms who are the borrowers and the banks who are their lenders. This crucial "micro" link between public and private investment via the credit market, has been explored in the first chapter of this dissertation. In a model island economy of sea faring entrepreneurs, we trace the effect of an archetypal public good - a lighthouse, on the credit market equilibrium of this hypothetical economy. Results indicate that the effects of the lighthouse on the credit market equilibrium not only have an impact on the optimal level of public inputs in an economy, but they also say something about the `targeting' of public inputs in an asymmetrically informed world. Public goods that are targeted to the low ability may dominate those available to all types. Thus, this chapter contributes to the debate on the precise linkages between infrastructure and economic development.

The second chapter explores the role of "social infrastructure" of an economy on shaping its business environment. Social infrastructure includes not only the physical infrastructure of an economy, but also its legal framework, business regulations, scope for corruption and need for irregular payments by firms etc... It has been observed that

those economies ranking high on this social infrastructure index consistently attract higher levels of domestic and foreign investment, as compared to economies plagued with corruption and poor social infrastructure. In a simple theoretical model that explicitly takes into account such factors, it is shown why a lender (presumably a bank) would look to these economy wide indicators instead of firm-specific indicators to determine its lending decisions. It is concluded that in contrast to private signaling by firms in the credit market, these factors will increasingly be looked upon as `public' signals, which improve allocational efficiency in the credit market.

In the third chapter of the dissertation, the hypothesis about public inputs and its effect on the credit market proposed in the two chapters above is tested using world wide firm-level data based on a survey carried out by the World Bank Group (World Business Environment Survey (WBES), 2000). We concentrate on two sets of constraints faced by firms - financial constraints and the quality of public services. We show that the quality of infrastructure faced by firms crucially affects the financial constraints they face in the credit markets. Both Ordered Logit and Ordered Probit estimates validate the conclusion that taking care of all region specific and firm specific constraints, firms facing high infrastructural constraints are most likely to have high financial constraints as well. This link is seen to be stronger in the case of smaller and medium sized firms.

For my Parents.

ACKNOWLEDGEMENTS

Thanks firstly to my parents, for bearing with patience - the peregrinations of my career. Thanks to my Advisor, Professor Larry Martin for having the confidence in this work – at times, far exceeding my own. Thanks to my siblings, for providing the succor when most needed. Thanks to friends who were there to listen.

I began this work with the spirit, "De omnibus, es dubitandum" (Of all, one must doubt) – I hope I have succeeded.

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Public Inputs and the Credit Market

1.1 Introduction

There seems to be a renewed interest in the role of public goods which increase productive capacities of private firms [71]. Such goods, alternatively known as *intermediate public goods* or *public inputs* affect investment and production decisions of private producers in a collective manner. Broad examples include public infrastructure like roads and bridges, services like health-care and education in many countries, and provision of information through research institutes or agricultural extension centers. The macroeconomic role of such public sector capital has been dealt extensively using aggregate econometric models [51]. Such analysis however fails to clarify the precise "micro" linkages between provision of public inputs and the nature of the production process. Much of the analysis in this area is also implicitly based on the assumption of perfect information among participants. It is now amply clear that public interventions in an *imperfectly informed* world have qualitatively different implications compared to interventions in a first-best, perfect information world[44]. This paper therefore, plans to pursue one "micro" link where the role of the public input is analyzed in the absence of perfectly informed markets. It traces the effect of public inputs on private investment decisions of heterogenous entrepreneurs who have to borrow in credit markets characterized by asymmetric information. In turn, this paper also addresses a key question in public sector economics today [?] - In a world where asymmetric information is endemic, "What type of public policies can relax the self-selection constraints?"

Our model economy is a small, island economy of sea-faring entrepreneurs and we trace the effect of an archetypal public good - a lighthouse, on the credit market equilibrium of this hypothetical economy. An entrepreneurial project in this island economy involves entrepreneurs undertaking a sea-voyage. Entrepreneurs differ in their knowledge of the hazards en-route the sea-voyage - efficient entrepreneurs having better knowledge about the hazards compared to the inefficient. Potential entrepreneurs have to borrow funds from the capital market in order to undertake the project. The lenders in the credit market cannot distinguish, ex-ante, between the efficient and the inefficient entrepreneurs. A lighthouse reduces the risks associated with such a voyage and increases the probability of undertaking successful entrepreneurial projects, but it does so in an asymmetric way. It points out potential hazards at sea to the entrepreneurs undertaking the project. Since entrepreneurs differ in their abilities, the lighthouse benefits the inefficient entrepreneur more than the efficient. The lighthouse thus increases the degree of homogeneity in the abilities of entrepreneurs. This key result affects the credit market equilibrium in this economy.

The intuition behind this paper is gleaned from field studies carried out in the rural credit markets of several developing economies[47]. Information asymmetries between borrowers and institutional lenders like banks tend to be glaring in such markets as formal credit institutions are still in their nascent stages. One econometric study, for example[17], covering eighty five districts in thirteen Indian states has shown that there exist crucial linkages between public infrastructure and the process of financial intermediation. Government investment in infrastructure like roads, irrigation and regulated markets which reduced the risks that farmers faced, also facilitated the expansion of commercial banks in the rural areas. This result implies that government investment in infrastructure, by reducing production risks affect the pattern of information between the lenders and the borrowers. Public inputs, by reducing information asymmetries in the economy can thus play an important role in improving the equilibrium in the credit market.

The credit market model we consider is characterized by information asymmetries which are ex-ante. We essentially build on the model of Bester[16], where collateral plays a catalytic role as a private signalling device in the credit market equilibrium. However, in order to deal explicitly with both types of equilibria, separating and pooling, we refine the game being played in the credit market on the lines suggested by Hellwig[46]. Depending upon the degree of heterogeneity in this economy, the effect of the lighthouse on both, separating and pooling equilibria in the credit market, will be considered. The direct effects of a lighthouse are summarized in Samuelson's ΣMRS, while the indirect effects stem from the asymmetric information in the credit market. By separately considering these indirect capital market effects of the lighthouse, we can also say something about the 'type' of public goods that should be provided in an asymmetric information world.

As our intuition suggests, the results of this paper consistently point out the increased benefits from a lighthouse via the credit market. We see that public inputs, by lowering the agency costs which define a separating equilibrium in an imperfectly informed market, shift the second best Pareto frontier towards a more desirable pooling equilibrium. While they may not eliminate information asymmetries totally, they certainly expand the size of the information set available to the economy. This link between public and private investment is crucial, since financial intermediation is increasingly playing an important role in private investment decisions of most economies[40]. This additional benefit of a public input in a second best economy should not only have a bearing on policies determining the optimal level of public inputs, but also on the 'targeting' of such public inputs.

The paper is organized as follows - Section 2 introduces the model. In section 3 we discuss the separating equilibrium in the credit market. The effect of public inputs on the separating equilibrium is given in subsection 3.1. The issue of the pooling equilibrium is dealt in fair detail in sections 4 and 5. It is seen that increasing provision of public goods of particular types affect existence of the separating contracts in the capital market. This gives us some results on the targeting of particular types of public inputs. Section 6 enumerates the benefits of a lighthouse on the economy under both the regimes, separating and pooling. The necessary modifications to the Samuelson Rule for the provision of public goods are suggested. The paper ends with section 7, where we point out areas of further research and give the conclusions and some policy implications of our analysis.

1.2 Model

Agents: We consider a small island economy in which agents differ with respect to their innate ability a. A proportion γ of these agents is of low ability, denoted by a_L and $(1-\gamma)$ is of high ability, denoted by a_H. Whether an agent is type a_L or a_H is private information. Agents can take up entrepreneurial projects in this economy which involve a sea voyage. The risks on such a voyage are defined by the hazards en-route, which are N in number. So, ability in this economy corresponds to the knowledge that agents have about the hazards on this sea-voyage, and the potential entrepreneurs differ in their knowledge about the hazards. These N hazards can be thought of as being ordered on a scale of visibility. The most visible and obvious hazards are known to all agents, and the less obvious are known only to the efficient types. Agents of type a_H are aware of M_H hazards and agents of type a_L are aware of M_L hazards en route. $M_L < M_H < N$. Additionally, we assume $(M_L) \subset (M_H)$. The type a_H entrepreneurs are aware of all the hazards known to the type a_L.

All agents in this economy are identically endowed with one unit of labor (l) which they supply inelastically. We assume initially that all agents are also identically endowed with with a physical endowment, w. We assume that $w < 1$, and w can be used either for consumption or investment. These agents are risk neutral and live for two periods. They produce in the first period and consume in the second period. Agents have two distinct choices: to be workers and work in a 'routine' activity, or to be potential entrepreneurs and embark on an entrepreneurial project involving a sea voyage. Workers are assumed supply only and for their labor, each worker gets a deterministic return Z_i. Efficient workers get a higher return denoted by Z_H, as compared to the inefficient agents who get Z_L. We assume,

A 1 $Z_H > Z_L$.

This assumption implies that efficient types dominate with respect to this 'routine' activity also and as we shall see below, this assumption is important to the results in this model.

The potential entrepreneurs combine their labor with one unit of capital (k) and embark on the entrepreneurial project. One unit of capital(k) is invested in the project one period ahead of time, and it fully depreciates after one period of production. Potential entrepreneurs have to borrow this one unit of capital (k) in order to undertake the project. In addition, we assume that they can only use w as collateral to obtain capital (k) for investment. If the project ends in a ship-wreck, they forfeit their collateral.

Banks: Banks are special firms which operate as delegated monitors for many lenders as described by Diamond [35]. Banks in this economy are risk-neutral and act as Betrand Competitors in a market where they obtain elastically supplied funds. We normalize the gross deposit rate at which the banks obtain these funds to be one. Since we assume banks to be Betrand competitors, they make zero profits in equilibrium on the projects they lend.

Projects: The returns from the entrepreneurial projects have the following characteristics — they are:

(a) Uncertain - A successful project yields $y > 0$, while an unsuccessful project, which involves a ship-wreck, yields nothing.

(b) The returns depend upon the ability of the entrepreneur. Agents of type a_H (efficient) have a higher probability of making the project a success, as compared to the type a_L (inefficient) agents. We make a simplifying assumption that a type a_H agent has a success probability given by $\frac{M_H}{N}$, and a type a_L agent has a success probability given by $\frac{M_L}{N}$. Thus the ability of the entrepreneurs in making a success of their project is linked to their knowledge of the hazards on the sea journey, i.e., $\frac{M}{N}i$ $i \in \{H, L\}$. The efficient agents get higher expected returns from the project as compared to the inefficient agents, $\frac{M_H}{N}y > \frac{M_L}{N}y$. In this model, following DeMeza and Webb [28], we assume that the distribution of returns to the high ability (low risk) borrower exhibits first order stochastic dominance (FOSD) over the distribution of returns to the low ability (high risk) borrower.[1] Here, the high ability types get higher returns in all activities they undertake. The opportunity cost of entrepreneurship are higher for the more efficient. So, an efficient type will invest in the project only if the net returns from the project exceed his opportunity costs.[2]

(c) high yielding - We explicitly assume 'high yielding' to be,

A 2 $\frac{M}{N}i \quad y - 1 > Z_i$. *The expected value of the net returns from the project exceed the opportunity cost of the project to all agents.*

[1] This is in contrast to the Stiglitz-Weiss [65] model, where distribution of returns to the high risk is a mean preserving spread of the distribution of returns to the low risk (SOSD).

[2] This assumption is also in consonance with Spence's labor-market signalling model, where the reservation wages of the high ability are higher.

While $\frac{M_i}{N} - 1$ are the expected returns and 1 is the value of the borrowed capital, this assumption implies that there exist incentives for all agents to undertake the project.

Public goods 'g' in the nature of infrastructure: The economy has to be provided with 'g', which has the characteristic of a pure public good, in this case - a lighthouse. It is non-rival and non-exclusive in use. How g enters into the decision making process will be explained below. It is assumed that the level of infrastructure 'g' plays a critical role in determining the success probabilities of the project. A lighthouse points out additional hazards on the sea-route to all entrepreneurs. Since the hazards can be ranked in increasing order of their visibility - a lighthouse will typically result only in two possibilities,

(A)The targeted public good: a lighthouse which will bring to light one hazard known to the efficient type, but not to the inefficient type, or

(B)The pure public good: a lighthouse which will bring to light one hazard, unknown before to both types.

In Scenario (A), we are restricting ourselves to public goods which directly benefit only the low-ability types in the economy. The lighthouse here, directly benefits only the type a_L, since the type a_H was aware of this hazard before.

We define the effect of this lighthouse (A) as per the following, $\forall i \in \{H, L\}$,

$$\frac{dU_i}{dg_{(A)}} = \frac{\partial U_i}{\partial M_L}\frac{dM_L}{dg_{(A)}} \quad \text{where} \quad \frac{dM_L}{dg_{(A)}} = 1. \text{ and } \quad \frac{dM_H}{dg_{(A)}} = 0$$

Scenario (B), on the other hand, is the general case - public goods benefit both types in the economy, efficient as well as the inefficient. With the provision of the lighthouse, both M_H and M_L increase by one in this case. We can define the effect of this lighthouse (B) as per the following, $\forall i \in \{H, L\}$,

$$\frac{dU_i}{dg_{(B)}} = \frac{\partial U_i}{\partial M_L}\frac{dM_L}{dg_{(B)}} + \frac{\partial U_i}{\partial M_H}\frac{dM_H}{dg_{(B)}} \quad \text{where} \quad \frac{dM_L}{dg_{(B)}} = \frac{dM_H}{dg_{(B)}} = 1.$$

We then have the following,

> **Proposition 1** *In both scenarios, (A) and (B), the lighthouse increases the homogeneity in the economy. However, this increase in the homogeneity is higher with $g_{(A)}$ as compared to $g_{(B)}$.*[3]

The intuition behind this proposition is that the lighthouse affects the productivity of entrepreneurs in an asymmetric way. So, while the direct effect of the lighthouse on the productivity of entrepreneurs is obvious, we have to consider the 'indirect' effects which stem from reduced heterogeneity in the economy. We trace this indirect effect through the capital market. Additionally, by considering both these effects, the direct and the indirect, we will also be able to compare the two scenarios (A) and (B). This will basically tell us something about the "type" of public goods that should be built - $g_{(A)}$, which benefit mainly the less-able in the economy, or $g_{(B)}$, which benefit all.

[3] If we assume $\frac{M_L}{M_H}$ to summarize the degree of homogeneity, then proposition (1) states that $\frac{M_L}{M_H}$ increasing. Not all public inputs may have this property. To take a concrete example, in providing public services like setting up public research institutes, or providing information about high yielding agricultural techniques and inputs to farmers (both actively pursued by the Indian government during the 'green revolution' in the 1970's), the focus could be specifically on benefiting the most productive sectors. In this case, $\frac{M_L}{M_H}$, the degree of homogeneity in the economy will fall. However, by making our assumption of $\frac{M_L}{M_H}$ increasing - we essentially hope to capture the nature of benefits derived from most basic infrastructure goods and services.

1.3 The capital market and the separating equilibrium

In this section we consider the capital market where the information asymmetry is ex-ante viz., the borrowers know whether their success probability is $\frac{M_L}{N}$ or $\frac{M_H}{N}$, but banks only know the average ability of the entrepreneurs applying for loans.

The optimal lending contract: Assume there exists only a standard debt contract for investing funds (issuing equity is costly). As in the model of Bester [16], banks offer a loan contract consisting of a pair $\langle r, c\rangle$ where r is the gross interest rate charged and c is the collateral that the borrowers are willing to put up. Similar to the Besanko and Thakor model [15], we make the following additional assumption,

A 3 *Collateralizing is costly. Collateral of value c_i to the borrower gives to the bank a value of βc_i, in the event the borrower defaults, where $\beta \in (0,1)$.*

Note that apart from having real world justification, this assumption is also crucial for the existence of equilibrium in a risk neutral environment[26]. As in model given by Hellwig [46], the a 3 stage sequential game is being played in the credit market. This game explicitly takes into account dynamic reactions of borrowers. It is played as follows,

Stage I : Loan contract offer made by banks, the uninformed player in the game, $\langle r_i, c_i\rangle$.

Stage II: The informed players, the borrowers, choose to apply for contracts they view as most attractive. Each borrower can apply only for a single contract.

Stage III: The Bank may accept or reject the loan applications they have received in stage II.

The optimal contract $\langle \hat{r}_i, \hat{c}_i \rangle$; $\forall i = H, L$ is a set of contract offers which determine the equilibrium in this 3 stage game. i.e. given $\langle \hat{r}_i, \hat{c}_i \rangle$ $\forall i = H, L$

- Banks make zero profits on each contract and

- No bank has the incentive to offer a different loan contract than the ones offered.

Since this game is sequential, the equilibrium considered will be the sub-game perfect or sequential equilibrium. The usual condition that each agent's strategy be the best response to the other agents' strategies is applied not only to the overall game, but to every decision node in the game tree, regardless of whether this node is reached in equilibrium. We define U_{ij} to be the utility to agent of type i applying for a loan contract meant for type j, and it is given as:

$$U_{ij} = \frac{M_i}{N}(y - r_j) - (1 - \frac{M_i}{N})c_j - Z_i$$

The problem for the bank is,

$$\underbrace{Max}_{\{r_i, c_i\}} \quad \gamma U_{LL} + (1-\gamma)U_{HH} \qquad s.t.$$

(i) the Zero profit constraint for the banks: $\frac{M_i}{N}r_i + (1 - \frac{M_i}{N})\beta c_i = 1$.

(ii) the self selection constraints $U_{ii} \geq U_{ij}$.

Before analyzing the asymmetric information case, we solve for the perfect information case as a benchmark. The self selection constraints do not bind this case. We maximize U_{ii}, subject to the zero profit constraint of the banks (i), and the assumption that $\beta < 1$. We see that [*See Notes to Calculations*],

$$c_i = 0 \qquad \text{(No collateral).}$$

$$r_i = \frac{N}{M_i} \qquad i = \{H,L\}.$$

In the perfect information case, the interest rates charged by the banks reflect perfectly the risks (inverse of the entrepreneurial abilities) associated with the project. The low ability entrepreneur is charged a higher interest rate (r_L) than the high ability type, (r_H). These contracts cannot be optimal in the asymmetric information case, since both types would prefer contracts meant for the efficient types.

To see the equilibrium in the Asymmetric information case, totally differentiate U_{ii} to get the slope of the indifference curves of the borrowers in the r-c space,

$$\frac{dr_i}{dc_i} = -\frac{N - M_i}{M_i} \tag{1.1}$$

(1) establishes both the negative slope and the single crossing property of the indifference curves in the r-c space. The indifference curve of the inefficient borrower is steeper (has lower MRS) than the efficient borrower. The efficient borrower is less likely to default on account of a ship-wreck and lose his collateral. So, for a given decrease in the interest rate, an efficient type would be willing to post more collateral then the inefficient - this explains the reason for the higher MRS. Likewise, the expected returns to the bank (R_b) is given by $\frac{M_i}{N}r_i + (\frac{N-M_i}{N})\beta c_i$. Totally differentiating it we get the slope of the isorevenue curve for the bank in the r-c space,

$$\frac{dr_i}{dc_i} = \frac{-\beta(N - M_i)}{M_i} \tag{1.2}$$

Existence of a separating equilibrium requires:

(a) The isorevenue curves of the banks should be flatter than the indifference curves of the borrowers. In this case, assuming $\beta < 1$ assures us this.

(b) A condition on the composition of the economy, where we assume γ *is high. This* assumption - the presence of large number of low ability individuals, *ensures* us the existence of a separating equilibrium (See Rothschild and Stiglitz [60]).

For deriving the equilibrium contract $\langle \hat{r}_i, \hat{c}_i \rangle$, we see that w does not impose a binding constraint on collateral. For the equilibrium, the only self selection constraint which is binding is $U_{LL} \geq U_{LH}$ - the constraint *which* applies to the low-ability entrepreneur *mimicking* the high ability types.[4] This is used *in* solving for the optimal contracts and we get,[Proof in the Appendix],

Proposition 2

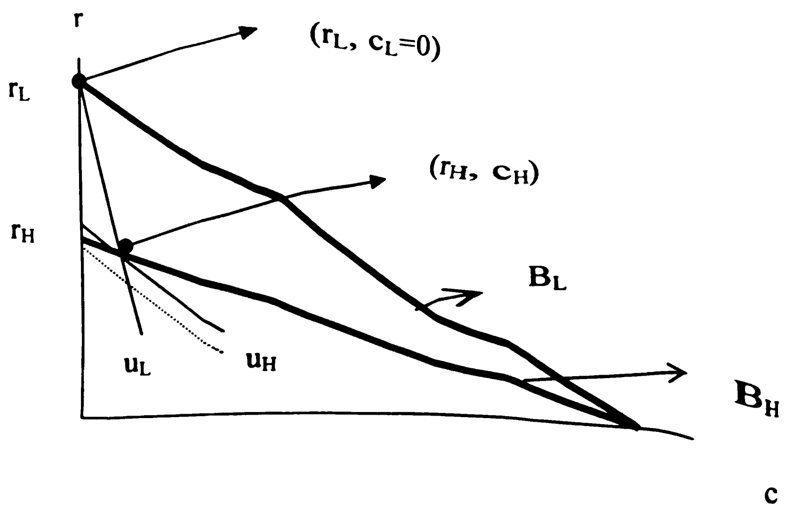
$$\hat{c}_L = 0 \qquad \hat{c}_H = \frac{N(1 - \frac{M_L}{M_H})}{N - \frac{M_L}{M_H}(M_H + \beta(N - M_H))}.$$

$$\hat{r}_L = \frac{N}{M_L} \qquad \hat{r}_H = \frac{N}{M_H} + \beta \hat{c}_H (1 - \frac{N}{M_H}).$$

In the process of self-selection, the low-ability types get the same contract as they would under the perfect information case, while the high-ability have to distinguish themselves by willing to pay collateral. Collateral in this economy has a cost. Since the low-ability borrowers pay higher interest rate than the high-ability borrowers, they have an incentive to mimic as the high-ability types. They must therefore be deterred from the choosing the contract meant for the high ability types. This is achieved by requiring the high-ability to post collateral, since it is onerous for the low-ability to post collateral.

[4] The optimal solution is obtained by conjecturing at first that $U_{HH} > U_{HL}$, so that there exists only one self-selection constraint which is binding, and which is given by $U_{LL} = U_{LH}$. After solving for the optimization problem, we can show that the solution satisfies our conjecture.(See Besanko and Thakor [15]).

Figure 1 - Separating Equilibrium in the Credit Market



Collateral sorts borrowers by type. The same is shown in the figure above where in the interest rate (r) and collateral (c) space, the U_H refers to the indifference curves of the high ability entrepreneurs. They are flatter than the indifference curves of the low ability entrepreneurs denoted by U_L. B_H refers to the zero-profit lines for the banks with respect to the high ability borrowers and B_L refers to the zero profit lines for the low ability borrowers. (r_L, c_L) and (r_H, c_H) are the equilibrium contracts for the low-efficiency and the high-efficiency types respectively.

After the self selection of the respective contracts in the credit market, the equilibrium payoffs of the two types of entrepreneurs are given as below,

$$\hat{U}_{LL} = \frac{M_L}{N}y - 1$$
$$\hat{U}_{HH} = \frac{M_H}{N}y - 1 - \hat{c}_H[(1-\beta)(\frac{(N - M_H)}{N})]$$

We see that the low ability entrepreneur ends up with a payoff equal to what he would have got in the perfect information case. On the other hand, the high ability entrepreneur's payoff is lower to the extent of the signalling costs which he has to incur in the form of collateral.

1.3.1 Public inputs and the separating equilibrium

Lighthouse (A) - The targeted public inputs We begin initially considering the lighthouse (A), which is directly beneficial only to the low ability types, since it only increases M_L, the hazards known to the low-ability types. The total benefits of g is calculated as follows

(i) "Direct" benefits: All the low-ability entrepreneurs face an increase in their expected returns due to a lowering of risks in the sea-voyage, given to be $\frac{y}{N}$ which is positive. This equals the marginal benefits of the lighthouse in a perfect information world as well.

(ii) "Indirect" benefits stemming from the capital market: These indirect benefits are basically of two types: (a) The benefits accruing from lower interest rates, due to marginally lower risk of a ship-wreck. The high-ability entrepreneurs do not get the benefit of reduced interest rates, but they benefit from (b) lower collateral costs, which is given as,

$$\frac{\partial U_{HH}}{\partial g_{(A)}} = -\frac{\partial \hat{c}_H}{\partial M_L}[(1-\beta)(\frac{N-M_H}{N})] \tag{1.3}$$

We see that $\frac{\partial \hat{c}_H}{\partial M_L} < 0$.[*See Notes to Calculations (II)*]. Therefore, we get $\frac{\partial U_{HH}}{\partial g_{(A)}} > 0$. Thus by lowering the amount of collateral that is required of the efficient types, public goods also reduce the "signalling costs".

This benefit of the lighthouse is peculiar to an asymmetric information environment, where the outcomes are pareto inefficient. The direct benefit of *the lighthouse* to the high-ability type is zero, because *he* has previous knowledge of the additional hazard. However in the credit market where the banks are unaware of types, he has to post collateral in order to signal his type. These signalling costs are directly related to the degree of heterogeneity in ability. The higher the difference in the *abilities of the two* types ($\frac{M_L}{M_H}$ is low), the higher is the cost borne by the high-ability *entrepreneur in terms of collateral. A public good* which increases the ability of the inefficient lowers the degree of heterogeneity *in* the economy. The intuition is that by decreasing the degree of heterogeneity, the lighthouse relaxes the self-selection constraint ($U_{LL} > U_{LH}$). As the self-selection constraint is relaxed, mimicking is no longer seen to be that attractive by the inefficient, and the costs of signalling to the efficient is reduced. This is reflected in the lower collateral for the efficient types.

(iii) "Entry effects": These arise in the case of the inefficient entrepreneurs, due to lower interest rates.

(ii) and (iii) are benefits of the lighthouse which accrue due to the inefficiencies in the credit market, arising from asymmetric information. Both these additional effects must have to be included in the Cost-Benefit analysis of the lighthouse, and they are discussed in section 6.

Lighthouse (B) - The pure public inputs Here, the lighthouse benefits both types of entrepreneurs. The benefits of this lighthouse are given by,

(i) "Direct" benefits to both types: Direct effects on the productivity of both types are given by the increase in the expected returns from the projects. In the case of the low-

ability, the expected returns rise by $\frac{y}{N}$, which is the same as in the case of the lighthouse (A). For the high-ability, his direct productivity benefits (which were zero in the previous case (A)), go up by the term, $(\frac{y}{N} + \frac{(1-\beta)}{N} c_H)$.

(ii) "Indirect benefits": The indirect benefits to the low ability accrue from lower interest rates, which remains the same as in the case of lighthouse (A). For the high-ability, the total benefits have to include the "indirect" benefits when stem from the capital market. The total benefits of the lighthouse (B) to the high-ability is given by,

$$\frac{\partial U_{HH}}{\partial g_{(B)}} = \frac{y}{N} + \frac{(1-\beta)}{N} c_H - (\frac{\partial c_H}{\partial M_L} + \frac{\partial c_H}{\partial M_H})[(1-\beta)(\frac{N-M_H}{N})].$$

The total benefits critically depend on the indirect 'capital' market effect, given by the term, $-\{(\frac{\partial c_H}{\partial M_L} + \frac{\partial c_H}{\partial M_H})[(1-\beta)(\frac{N-M_H}{N})]\}$. As we saw, $\frac{\partial c_H}{\partial M_L}$ is negative, but on the other hand, $\frac{\partial c_H}{\partial M_H}$ is positive [*See Notes, (II)*]. Therefore, this indirect capital market effect being negative or positive will depend upon the relative weights of these two terms. We then have the following proposition [Proof in the appendix],

Proposition 3 *Indirect capital market benefits of lighthouse (B), valued equally by all types, though positive, are of a lesser magnitude than the capital market benefits of lighthouse (A), valued only by the inefficient.*

The intuition is that a public input which has a greater impact on increasing the homogeneity in the economy leaves the inefficient with a lower incentive to masquerade. In the case of lighthouse (A), the increase in homogeneity is higher compared to lighthouse (B). Therefore with the provision of lighthouse (B), the resulting slack in the self-selection constraint is less, and the capital market benefits are lower in magnitude as compared to the lighthouse (A).[5] One has to then compare this capital market *externality with the* direct productivity benefits to find out whether the total benefits *of the lighthouse (B)* exceed that of lighthouse (A).

(iii) The entry effects: For the low ability, the entry effects remain the same as in the case of lighthouse (A).

SEPARATING EQUILIBRIUM.

	Lighthouse(A)	Lighthouse(B)
a_L	'Direct' effect (+) Interest rate effect (+)	'Direct' effect (+) Interest rate effect (+)
a_H	Capital Market effect (++)	'Direct' effect (+) Capital market effect (+)

The figure above summarises these conclusions (++ indicate benefits of a greater magnitude as compared to +). Under a separating equilibrium, the low ability entrepreneurs are indifferent between the lighthouses (A) and (B). The productivity and the interest rate benefits they get in either case are the same.

[5] This reason essentially sums up why a public input which is more valuable to the efficient will not have any positive spill-overs in the credit market. There is no relaxing of the self-sufficiency constraint - with such a good, $\frac{M_L}{M_H}$ decreases. So any public input which increases the ability of the efficient more than that of the inefficient increases the degree of heterogeneity in the economy. As mimicking is made more attractive, the collateral costs in the credit market increase.

The decision to choose between the types (A) and (B) then depends essentially, on the payoffs to the efficient entrepreneurs. While the indirect capital market benefits to the efficient types is higher with lighthouse (A), they derive positive direct productivity benefits with lighthouse (B). Suppose there exists a separating equilibrium in the credit market, and the government has funds to build a lighthouse, the targeted public input (lighthouse (A)) may dominate the pure public input (lighthouse (B)). Arriving at a definitive conclusion would therefore imply comparing the second order conditions of the capital market benefits, which is explored in section 5.

1.4 The "switch" to a pooling equilibrium

We have seen that by investing in lighthouses, the entrepreneurs are made less heterogenous as regards ability, and the sorting costs in terms of collateral are reduced. However this increased homogeneity can jeopardize the existence of a separating equilibrium in the economy[60], since existence of a separating equilibrium depends essentially, on the efficient types wanting to differentiate themselves from the inefficient by signalling. We now turn to the relationship between the public inputs and the nature of the equilibrium.

We saw that in the separating equilibrium denoted above, equilibrium pay-offs to the entrepreneurs are:

$$\hat{U}_{LL} = \frac{M_L}{N}y - 1$$
$$\hat{U}_{HH} = \frac{M_H}{N}y - 1 - \hat{c}_H[(1-\beta)(\frac{(N-M_H)}{N})]$$

Denote the term $\hat{c}_H[(1-\beta)(\frac{(N-M_H)}{N})]$ as S, where S refers to the 'sorting' cost. This sorting cost is the proportion of the of collateral forfeited as a dead-weight loss if the entrepreneur has a ship-wreck. The term $(\frac{M_H}{N}y - 1)$ gives the utility of the high-ability in the case of perfect information. So in an asymmetric information case, his utility is reduced to the extent of these 'sorting costs'.

Our next step is to show that there exists a pooling contract which dominates this separating equilibrium. We can then prove, along the lines of Hellwig[46], that the sequential solution to this game is a pooling equilibrium. A pooling contract does not differentiate between entrepreneurs. We begin by conjecturing that this pooling contract involves all entrepreneurs paying an average interest rate given by $\bar{r} = \frac{N}{\gamma M_L + (1-\gamma) M_H}$. (We will then prove in Proposition 4 that if this pooled contract Pareto dominates the separating equilibrium, then this contract is indeed the solution to this sequential game). The payoffs to the entrepreneurs under this pooled contract are given by,

$$\hat{U}_{L\gamma} = \frac{M_L}{N}(y - \bar{r})$$
$$\hat{U}_{H\gamma} = \frac{M_H}{N}(y - \bar{r})$$

We see that the low ability entrepreneurs would always prefer a pooled contract to the separating($U_{LL} \ll U_{L\gamma}$), but the preference of the high-ability types would depend upon the sorting costs S. Sorting costs or collateral costs in this economy are inversely related to $\frac{M_L}{M_H}$, the degree of homogeneity in the economy. We also see that the average interest rate under a pooled contract, $\bar{r}$, is inversely related to $\frac{M_L}{M_H}$. (The pooled interest rate is also inversely related to γ, the proportion of low-ability borrowers which we assume to be given as large). Thus we see that given the parameters β and γ, both S and $\bar{r}$ are inversely related to $\frac{M_L}{M_H}$. With the provision of a lighthouse which increases this homogeneity $\frac{M_L}{M_H}$, the sorting costs are reduced under a separating equilibrium, but the average interest rate under the pooling contract is also reduced. The efficient entrepreneurs will incur this sorting cost so long as they end up with a payoff which is more than the payoff they will get under a pooling contract. This defines a cut off S^* given by,

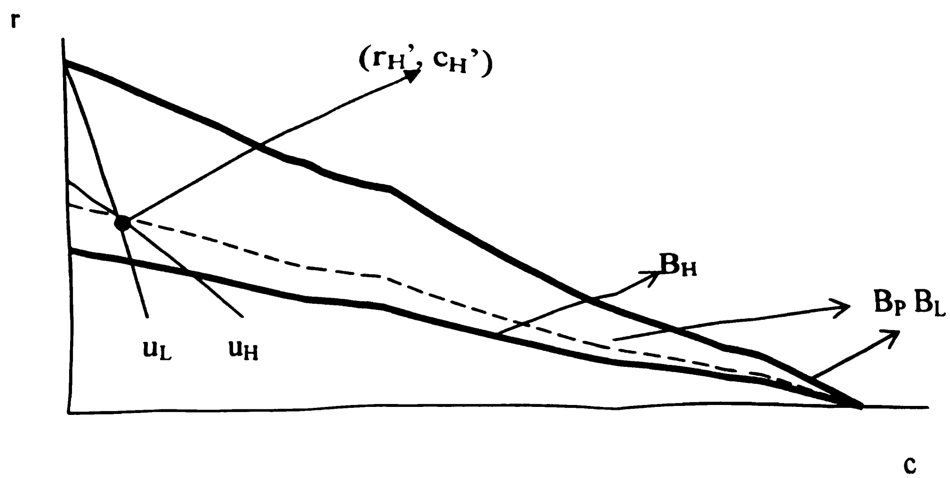
$$1 + S^*(g) = \frac{M_H}{N}\bar{r}(g) \tag{1.4}$$

With $S > S^*$, a pooling contract will Pareto dominate the separating contracts. This is shown in the diagram below, where B_L, B_H refer to the Zero Profit curve for the banks on contracts for low ability and high ability. The dashed line B_P refers to the Zero Profit curve for the pooled contract. U_L and U_H refer to the indifference curves of the low ability and high ability. $(r_L, 0)$ and (r_H, c_H) refer to the equilibrium separating contracts for the low-ability and the high-ability entrepreneurs respectively. The pooled zero profit line for the bank, B_P, lies below the indifference curve for the high-ability borrower.

The high-ability entrepreneurs, in this case will prefer a pooling contract to the separating one. (r', c') refers to one of the multiple pooling contracts which strictly dominates the separating contracts $(r_L, 0)$ and (r_H, c_H). The proof below establishes that among all of the multiple pooled contracts which dominate the separating contracts (all contracts like (r', c') which lie below the indifference curve of the high ability U_H and above the dashed line B_p, the zero profit line of the banks for pooled contracts), the only pooled contract which will be sustained as the equilibrium is the contract $(\bar{r}, c = 0)$ [Proof follows along the lines of Hellwig[46] and is given in the appendix].

Proposition 4 *Given that $S > S^*$, in the three stage game considered above, the sequential equilibrium of the game is given by the optimal pooling contract $\langle \bar{r}, c = 0 \rangle$.*

Figure 2: A Pooling Contract dominating the Separating Contracts



The proof thus relies on the refinement of the game being played in the credit market. It is because of the sequential nature of this three stage game, that out of the multiple pooling contracts which dominate the separating contract given above, there will persist only one pooling equilibrium given by $(\bar{r}, 0)$.[6]

While the inefficient entrepreneur always prefers the pooling contract as compared to the separating contract, the efficient entrepreneur's preference will depend on the collateral costs. The intuition is that given a level of heterogeneity among entrepreneurs, increasing signalling costs will dissuade the efficient entrepreneurs from differentiating

[6] Hellwig[46] mentions that this conclusion is reversed if the informed agents move first following the Cho and Kreps sequential equilibrium. However, following Wilson[69], we can assume that banks are unable to distinguish among agents before these agents choose the contracts. This might also reflect legal constraints, where it may required by law that all agents be given the same opportunities. Therefore, the uninformed party (the banks) moving first is a plausible assumption.

themselves from the inefficient types. They are better off under a pooled/undifferentiated contract. Increasing provision of public goods in the economy reduces the level of heterogeneity and thereby increases the probability of a pooled contract dominating the separating contracts.

1.5 "Switch Point" and the targeting of public inputs

From (4) we can calculate the critical point at which the pooling contract dominates, and the economy switches from a separating equilibrium to a pooling equilibrium. This "switch point" is given by [Calculation in the appendix],

$$\frac{1-\frac{M_L}{M_H}}{1-\frac{M_H}{N}} = \frac{(1-\gamma)(1-\beta)}{\gamma} \tag{1.5}$$

where γ, β are the given parameters.

In our analysis, the "switch point" is important, because it is a point of comparison, locally, between the benefits of a lighthouse under a separating equilibrium vis a vis the pooling equilibrium. Public goods which increase the homogeneity beyond this switch point results in the capital market having pooled contracts which dominate the separating contracts. A pooling equilibrium in this case, is socially optimal because it increases the utility of both types. We can compare the marginal benefits of both light-house (A) and (B) at this switch point defined above. This would tell us something about the choice of the lighthouses to be built.

Comparing the payoffs to the low-ability types under a pooling and a separating

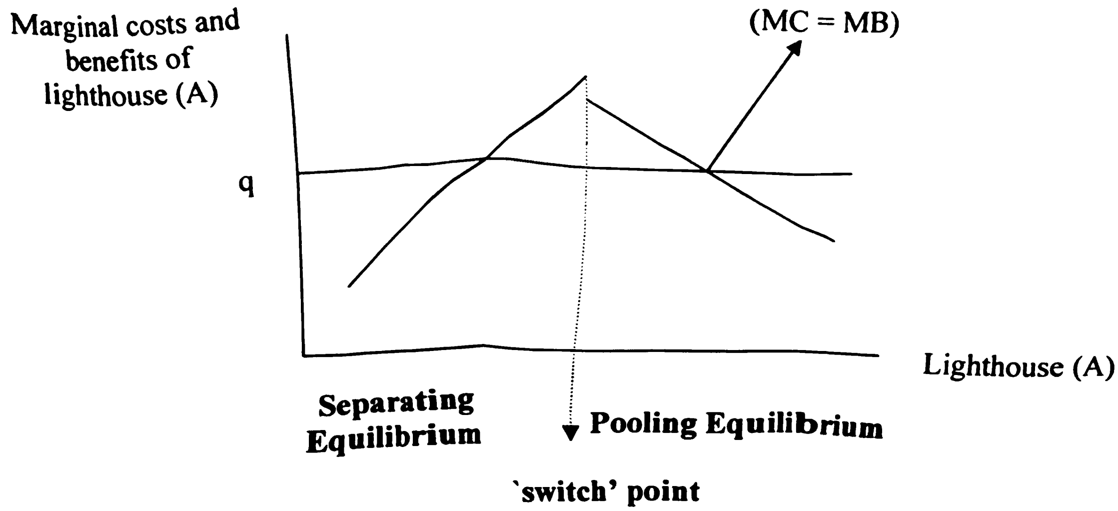


Figure 3: Targeted Public Input

equilibrium, with the provision of lighthouses of type (A), we find that the following holds, [Proof in the appendix],

Proposition 5 *At the switch point, the marginal benefits of lighthouse (A) are higher under a separating equilibrium as compared to the pooling equilibrium. The marginal benefits of the lighthouse (A) are however, increasing under the separating equilibrium till they reach the switch point. After this, the economy switches to a pooling*

equilibrium and the marginal benefits of the lighthouse (A) then start falling.

We see in the figure above that the switch point separates the separating and pooling equilibria. The marginal benefits (MB) are increasing when separating equilibrium ex

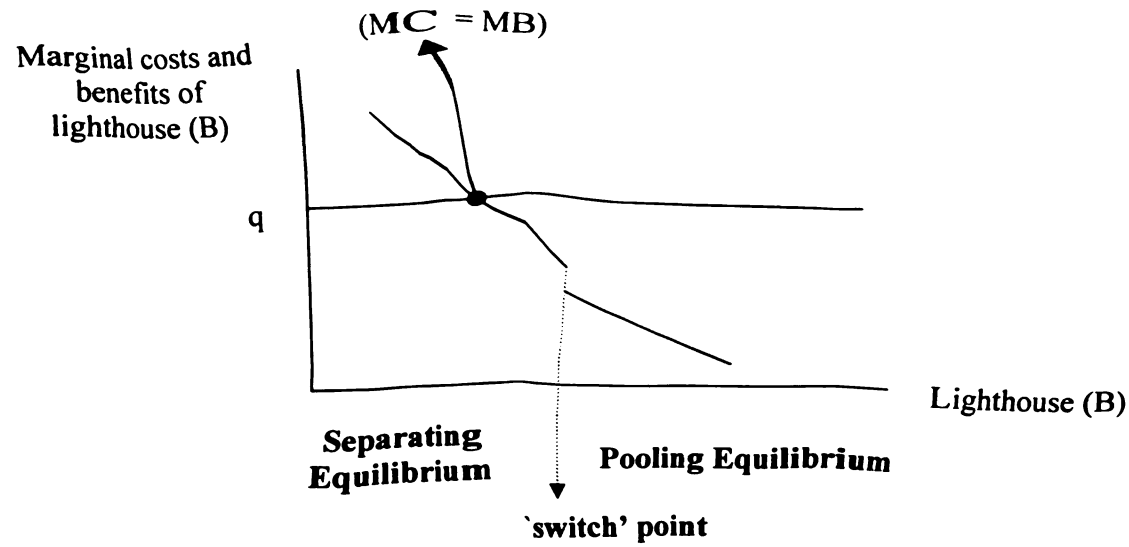


Figure 4: Pure Public Input

ists, and falling when pooling equilibrium exists. Given a constant marginal cost(MC) of building the lighthouse q, the optimal amount of lighthouse (A) (where $MB = MC$) leads to a pooling equilibrium. On the other hand, doing a similar analysis of lighthouse(B), we get the following[Proof in the appendix],

Proposition 6 *At the switch point, the marginal benefits of the lighthouse (B) are higher under the separating equilibrium, as compared to the pooling equilibrium. The marginal benefits of the lighthouse (B) are however, decreasing both under the separating and pooling equilibria. However, the optimal amount of lighthouse (B) leads to a separating equilibrium.*

In the figure above we see that in our model, to the left of the switch point we have increased heterogeneity among agents, associated with a low level *of public inputs in the* economy. The separating equilibrium dominates here. In this *scenario, a public good like* lighthouse(A) which is valued more by the inefficient in the economy exhibits increasing marginal returns. The reason being that the extent of private signalling through collateral is high at this level and therefore greater benefits accrue to the efficient entrepreneur through reduction in these private signalling costs. Lighthouse (B) on the other hand, *benefits* all entrepreneurs and reduces the *heterogeneity* in the economy to a lesser extent. *The indirect capital* market effects in the case of lighthouse (B) therefore increase at a *decreasing rate.*

The *above propositions* then suggest that given the a constant marginal cost q of building lighthouses - in an economy where the level of heterogeneity is high ($\frac{1-\frac{M_L}{M_H}}{1-\frac{M_H}{N}} < \frac{(1-\gamma)(1-\beta)}{\gamma}$), the optimal choice would be building lighthouses of type (A). The optimal level of the lighthouses of type (A) take the economy beyond the switch point, where the pooled contract dominates. On the other hand, building lighthouses of type (B) would make the economy persist with separating contracts in the capital *market. Thus,* considering the indirect capital market benefits - we would always end up *with* pooling equilibrium, *if* we build lighthouses of type (A). Therefore, when sorting costs are high in the credit market indicating a greater level of heterogeneity among borrowers, building public inputs which benefit the inefficient results in the maximum capture of the *externality* of the public input which accrue through the capital market. To the right of the switch point, under a pooling equilibrium however, we have to compare the benefits from the two types again to make a choice. This is done in the following section.

1.5.1 Public inputs and the pooling equilibrium

Lighthouse A The total benefits of the lighthouse (A) are calculated as follows,

(i) "Direct" benefits to the low ability, given as $\frac{y}{N}$. There are no direct benefits to the high-ability, as before.

(ii) "Indirect" effects stemming from a reduction in the pooled interest rates $\frac{\partial \bar{r}}{\partial g}$, will benefit both types. Essentially, with the provision of a public good which increases the *average* ability of entrepreneurs in the economy, the risks associated with lending are lowered, and this gets reflected in the lower interest rates.

(iii) "Entry" effects in this case, also will benefit both types. Depending upon the opportunity costs of the alternative foregone, with the reduction in the interest rates more entrepreneurs will enter the fray.

Lighthouse B All these three effects are also reflected in the case of lighthouse (B) which benefits both types. Additionally, the high-ability also benefits from the direct productivity effects. We also see that the fall in the interest rate, $\frac{\partial \bar{r}}{\partial g}$, which summarizes the capital market effect is greater in magnitude to both types in this case, as compared to the lighthouse (A). Thus in a regime where the pooling contract dominates, there will be an unambiguous choice in favor of the lighthouse (B) by both types. The same is shown in the figure above, where there is a comparison of the benefits under the pooling equilibrium. (++ refers to benefits of greater magnitude as compared to +). Thus to the right of the switch point, where the pooled contracts dominate in the capital markets - the optimal choice of the type of lighthouse to be built is B., those which benefit all entrepreneurs in the economy.

POOLING EQUILIBRIUM.

	Lighthouse(A)	Lighthouse(B)
a_L	'Direct' effect (+) Interest rate effect (+)	'Direct' effect (+) Interest rate effect (++)
a_H	Interest rate effect (+)	'Direct' effect (+) Interest rate effect (++)

We have *thus arrived* at a rough guideline for the 'type' of public inputs that should be provided in an economy. The results suggest that there is a key relationship between the type of public inputs and the degree of heterogeneity in the economy. When the heterogeneity in the economy is high, the transactions costs incurred in order to achieve the separating equilibrium are high. In such a scenario, a public input which is beneficial only to the low-ability types results in higher benefits as compared to a public good which benefits all types in the economy. So, an economy should begin by building public inputs which are targeted towards benefiting the less-efficient in the economy. This will result in maximum exploitation of the externality which accrue to the economy via the capital market. With such public inputs, the economy will end up having a pooled contracts which Pareto dominate the separating contracts in the credit market. After building a critical level of such public inputs, only then should public goods which benefit all types should be built.[7] In other words, if we explicitly take into consideration

[7] Our result can also be seen to be in consonance with Boadway and Keen [20], where using a different

the indirect benefits of public inputs via the capital markets, those *public inputs which are targeted to benefiting the inefficient in the economy provide the greatest benefits.* Provision of public inputs which benefit all, or which benefit only the efficient in the economy should be taken up only after building a critical mass of such targeted public inputs.

1.6 Optimality Rule for lighthouses

This section explores the optimality rules for the provision of the lighthouse using non-distorting, *lump-sum* taxation.[8] We shall be considering the costs and benefits of the lighthouse to the entrepreneurs under the two cases analyzed above. (I) In the separating equilibrium, and (II) where we have a pooling equilibrium.

(I) Effect of a lighthouse on the Separating Equilibrium: The optimal provision of lighthouses of type (A) will never result in the separating equilibrium, therefore the cost-benefit analysis in this case will be restricted to lighthouses of type (B), where the marginal benefits are declining. The government maximizes the Welfare (W) among the entrepreneurs, which is given as

$$\underbrace{Max}_{g(B)} W = n_L U_{LL} + n_H U_{HH} + n_b \pi_b - T$$
$$s.t. \quad q g_{(B)} = T$$

information structure than ours, they conclude that there should be a conventional "over-supply" of public goods which are more valuable to the less efficient, and a conventional "under-supply" of public goods which are valuable to the efficient.

[8] Since labor is non-elastically supplied in this model, it does not require any additional assumptions.

n_L, n_H and n_b refer to the number of low ability, high ability entrepreneurs and the number of banks respectively. π_b is the profits of the banks, which is zero in equilibrium. W is maximized s.t. the Government Budget constraint, where q refers to the cost of the lighthouse[9].

$$W = n_L(g_B)[\frac{M_L}{N}y - 1] + n_H(g_B)[\frac{M_H}{N}y - 1 - c_H(1-\beta)(\frac{N - M_H}{N})] - qg_B \quad (1.6)$$

Maximizing W with respect to g we get the following,

$$\frac{\partial W}{\partial g_B} = \Sigma n_i(\frac{y}{N}) + n_H[c_H\frac{(1-\beta)}{N} - \frac{\partial \hat{c}_H}{\partial g_B}(1-\beta)(\frac{N-M_H}{N})] + n_L'(g_B)(U_{LL}) + n_H'(g_B)(U_{HH}).$$

$\Sigma n_i(\frac{y}{N})$ are the "direct" productivity effects referred to in the Samuelson Rule as $\Sigma MRS_{y,g}$. The term in the square brackets refers to the "indirect" capital market effects. The n_i's refer to the "entry" effects.

(II) In the case of the pooling equilibrium, 'g' refers to both types of lighthouses, (A) and (B). The government maximizes welfare (W) with respect to g,

$$W = \Sigma n_i(g)[\frac{M_i}{N}(y - \bar{r})] + n_b\pi_b - T$$

$$s.t. \quad qg = T$$

Maximizing W with respect to g and the government budget constraint we get,

$$\frac{\partial W}{\partial g} = \Sigma n_i(g)[\frac{y}{N} - \frac{\bar{r}}{N}(\frac{\partial \bar{r}}{\partial g})] + \Sigma n_i'(g)U_{ii}. \quad (1.7)$$

$\frac{y}{N}$ are the direct productivity effects which can referred to as $\Sigma MRS_{y,g}$. The indirect capital market effects are seen through a reduction in the pooled interest rates, $\frac{\partial \bar{r}}{\partial g}$ being negative. The n_i's refer as before, to the "entry" effects. Using the above notational

9 The lighthouse is assumed to be built at a cost q, which is given ex-ante.

conveniences, the effect of a lighthouse in this economy can be summarized as,

$$q = \Sigma MRS_{y,g} + \textit{`capital market'}\text{ effect} + \textit{`entry'}\text{ effect}.$$

1.7 Conclusion

This paper makes two contributions. Firstly, it analyzes the role of public inputs from an information theoretic approach. Public sector economics is increasingly realizing the importance of imperfect information as a constraint on public policy. Private (asymmetric) information limits the set of allocations that can be achieved in an economy. While the nature of information asymmetry between the government and individuals has been analyzed[20], this paper traces the effect of public inputs when asymmetries exist among individual transactors. Market allocations in this second best world are often defined by contracts which are designed to prevent the inefficient from mimicking the efficient (separating equilibrium), or by contracts which go by the average attributes in the economy (pooling equilibrium). When separating equilibrium exists, one of the tests of an effective public policy is its ability to relax the self-selection constraints. We show in our model that a public intermediate good, by reducing the heterogeneity among borrowers is able to relax this self-selection constraint in the credit market. Those public inputs which are better equipped to reduce this heterogeneity have higher indirect spill-overs. Therefore, when the level of public goods in the economy is low, our model predicts that public goods which are valued more by the inefficient (lighthouse(A)), should be provided. An optimal provision of such targeted public inputs results in the pooled contracts dominating the separating contracts in the credit market. Here, the *targeted public input* dominates the pure public input. In other words, it makes sense *to restrict access to* public inputs when the marginal cost of another user is zero. When the credit markets are characterized by the pooling equilibrium, public inputs of both types, improve the average, (in this case the average quality of loans made), and encourage further lending in the economy. Public intermediate goods can thus be perceived as "public signals" *which* determine the level of socially optimal investment.

Secondly, in the light of the above, this paper calls for a re-assessment of the Cost-Benefit *analysis of public* inputs. Infrastructure and other public inputs can be justified without *reference to the* credit market - and yet, we have seen above that the indirect spill-overs from the credit market are too large to be ignored. This result has key policy implications in determining the optimal level of public intermediate goods in any economy. One has to go beyond $\Sigma MRS_{y,g}$ given by the Samuelson rule in the case of public inputs. This is especially crucial since private investment decisions cannot be de-linked from the outcomes in the credit market.

There is scope for further work in this area. The information asymmetry *in the credit* market is ex-ante, giving rise to the problem of adverse selection. An extension to this model would be considering the effect of public inputs when the credit market is also plagued by moral hazard issues. Secondly, the taxes considered in this model were non-distortionary. Further work can also be done on the nature of distortionary taxes and their effect on the marginal factor cost of building this lighthouse.

This analysis also has implications for real world public policy, especially, government policies in the credit market. Much of the analysis on public interventions in the credit market veers around the optimal level of subsidies and loan guarantees to lenders[61, 38] or redistributive policies[10, 49], which improve credit allocations. This paper on the other hand, deals with public provision of basic inputs like infrastructure, health, literacy and other services and its effect on the credit market. The main feature of such public inputs is that an increase in their provision leads to a narrowing of the spread of abilities among agents. We show that it is precisely this feature of public inputs which relaxes the self-selection constraints and achieves pareto optimal improvements in credit allocation. This feature of the public inputs also allows us to make conclusions about the targeting of public goods to specific sections of the economy. There is thus a need to carry out more dis-segregated analysis of public sector capital. As we have shown, the effects of public inputs on the economy differ, depending on the type of the public input considered.

More importantly, it is seen that public expenditures on infrastructure and provision of services like education and health are normally justified on grounds of equity as being expenditures on 'merit' goods, or as interventions in the production of goods having significant positive externalities. This analysis points out to another equally important justification: public inputs, by equalizing ex-ante abilities among agents can relax the self-selection constraints and improve the efficiency of market allocations. The ability of various public inputs to achieve this slack in the incentive constraints differs. In the light of this result, both the quantum of government expenditures, and the areas in which it is being spent, needs to be re-examined.

1.A Appendix

I. Proof of Proposition 2:

The problem for the bank is,

$$\underbrace{Max}_{\{r_i,c_i\}} \quad \gamma U_{LL} \quad + \quad (1-\gamma)U_{HH} \qquad s.t.$$

(i) the Zero profit constraint for the banks: $\frac{M_i}{N}r_i + (1-\frac{M_i}{N})\beta c_i = 1$.

(ii) the self selection constraint $U_{LL} \geq U_{LH}$.

The usual strategy is conjecturing that the *self* selection constraint which is binding is $U_{LL} = U_{LH}$. We later verify that the optimal solution does satisfy the second self selection constraint $U_{HH} > U_{HL}$. Substituting (i) into the utility function subject to (ii) gives us,

$$\underbrace{Max}_{\{c_H, c_L\}} L = \gamma[\frac{M_L}{N}(y - \frac{N}{M_L} - \beta c_L(1-\frac{N}{M_L})) - c_L(1-\frac{M_L}{N}) - Z_L] + (1-\gamma)[\frac{M_H}{N}(y - \frac{N}{M_H} - \beta c_H(1 - \frac{N}{M_H})) - c_H(1-\frac{M_H}{N}) - Z_H] + \lambda[\frac{M_L}{N}(y - \frac{N}{M_L} - \beta c_L(1-\frac{N}{M_L})) - c_L(1-\frac{M_L}{N}) - Z_L] - [\frac{M_L}{N}(y - \frac{N}{M_L} - \beta c_H(1-\frac{N}{M_L})) - c_H(1-\frac{M_L}{N}) - Z_L].$$

Where λ is the lagrangian multiplier associated with (ii). Setting $\frac{\partial L}{\partial c_H} = 0$ gives us,

$$\lambda \;=\; \frac{(1-\gamma)[(1-\frac{M_H}{N})(\beta-1)]}{(1-\frac{M_L}{N})(\beta-1)} > 0.$$

Which implies that (ii) is binding. Using the above result, it is easy to show that $\frac{\partial L}{\partial c_L} < 0$, which implies that $c_L = 0$. Putting this into (i), we get $r_L = \frac{N}{M_L}$. Putting these results in (ii), we get,

$$c_H = \frac{1-(\frac{M_L}{N}r_H)}{1-\frac{M_L}{N}}$$

We substitute for r_H from (i), and solve for the same above to get the optimal value $\hat{c}_H$.

We get,

$$\hat{c}_H = \frac{N(1 - \frac{M_L}{M_H})}{N - \frac{M_L}{M_H}(M_H + \beta(N - M_H))}$$

It can easily be verified that $U_{HH} > U_{HL}$, and that our conjecture was right■

II.Proof of Proposition 3:

The benefits to the high ability through lighthouse (A) is given by,

$$\frac{\partial U_{HH}}{\partial g_{(A)}} = -(\frac{\partial c_H}{\partial M_L})[(1-\beta)(\frac{N - M_H}{N})] \quad (1.8)$$

Using the definition of c_H given in Proposition 2, we can write,

$$\frac{\partial c_H}{\partial M_L} = \frac{NM_H(1-\beta)(M_H - N)}{[M_H(N - M_L) - \beta M_L(N - M_H)]^2} \quad (1.9)$$

We see that (1.9) is negative since $(M_H - N)$ is negative. Therefore, (8) is positive. The benefits to the high ability through lighthouse (B) is given by,

$$\frac{\partial U_{HH}}{\partial g_{(B)}} = \frac{y}{N} + \frac{(1-\beta)}{N}c_H - (\frac{\partial c_H}{\partial M_L} + \frac{\partial c_H}{\partial M_H})[(1-\beta)(\frac{N - M_H}{N})]. \quad (1.10)$$

From (1.9) we know that $\frac{\partial c_H}{\partial M_L}$ is negative. $\frac{\partial c_H}{\partial M_H}$ is then given by,

$$\frac{\partial c_H}{\partial M_H} = \frac{NM_L(1-\beta)(N - M_L)}{[M_H(N - M_L) - \beta M_L(N - M_H)]^2} \quad (1.11)$$

(1.11) is positive. Therefore, the condition for Proposition (3) to hold is that,

$$|\frac{\partial c_H}{\partial M_L}| > |\frac{\partial c_H}{\partial M_H}|$$

$$\Rightarrow M_H(N - M_H) > M_L(N - M_L)$$

$$\Rightarrow N > \frac{M_H^2 - M_L^2}{M_H - M_L}$$

$$\Rightarrow N > M_H + M_L$$

Which is true as per our assumption■

III.Proof of Proposition 4:

Suppose bank j deviates from the pooling contract $\langle \bar{r}, 0 \rangle$ and offers another contract $\langle \bar{r}, \bar{c} \rangle$ - it will be accepted by all the high ability and not the low ability. Since the high ability types are more likely to accept a contract involving collateral to signal their ability. Consequently bank j receives applications from all the above average, high ability entrepreneurs. Banks that have offered $\langle \bar{r}, 0 \rangle$, will then be left with below average sample of the population. Since $\langle \bar{r}, 0 \rangle$ only breaks even at the population average, all applications to $\langle \bar{r}, 0 \rangle$ will be rejected in Stage III. Knowing these rejection strategies, all entrepreneurs, both efficient and inefficient, will apply only for $\langle \bar{r}, \bar{c} \rangle$. This is contrary to our earlier assumption that only the high-ability will apply for this contract. Thus, under equilibrium strategies, deviations to the optimal pooling contract will be rejected and it cannot be upset by any separating contract $\langle \bar{r}, \bar{c} \rangle$. Therefore, $\langle \bar{r}, 0 \rangle$ will be the equilibrium pooling contract, and the sequential solution to this 3 stage game considered■

IV.Calculation of the 'Switch Point':

As per (1.5), the definition of the switch point, we have

$$N + c_H(1-\beta)(N - M_H) \quad = \quad M_H \bar{r} \tag{1.12}$$

Using the definition, $\bar{r} \equiv \frac{N}{M_H - \gamma(M_H - M_L)}$, we have

$$c_H(1-\beta)(N - M_H) \quad = \quad \frac{N\gamma(M_H - M_L)}{M_H - \gamma(M_H - M_L)}$$

Using the definition, $c_H \equiv \frac{N(M_H - M_L)}{M_H(N - M_L) - \beta M_L(N - M_H)}$, we have

$$\frac{(1-\beta)(N - M_H)}{M_H(N - M_L) - \beta M_L(N - M_H)} \quad = \quad \frac{\gamma}{M_H - \gamma(M_H - M_L)}$$

Which gives us,

$$(1-\beta)NM_H - (1-\beta)\gamma NM_H + (1-\beta)\gamma NM_L - (1-\beta)M_H^2 + (1-\beta)\gamma M_H^2$$
$$= \gamma NM_H - \beta\gamma NM_L$$

And this implies,

$$\begin{aligned}
NM_L(\gamma) &= M_H^2((1-\beta)(1-\gamma)) - NM_H((1-\beta)(1-\gamma)-\gamma) \\
\Rightarrow M_L &= M_H[\frac{M_H(1-\beta)(1-\gamma) + N(\gamma-(1-\beta)(1-\gamma))}{\gamma N}] \\
\Rightarrow M_L &= M_H[1 - \frac{(N-M_H)}{N}\frac{(1-\beta)(1-\gamma)}{\gamma}] \\
\Rightarrow \frac{1-\frac{M_L}{M_H}}{1-\frac{M_H}{N}} &= \frac{(1-\gamma)(1-\beta)}{\gamma} \blacksquare
\end{aligned}$$

V.Proof of Proposition 5:

At the switch point, the payoffs to the high-ability entrepreneurs with a separating contract just equal the payoffs they would get with an undifferentiated/pooled contract. This payoff is defined as per equation (1.12).

Separating Equilibrium:- For the type a_L entrepreneur, it is easy to see the marginal benefit of the light house (A),

$$\frac{\partial U_{LL}}{\partial g_{(A)}} = \frac{\partial U_{LL}}{\partial M_L} = \frac{y}{N} \tag{1.13}$$

From (1.8) and (1.9), we can calculate the marginal benefit of lighthouse (A) to the type a_H entrepreneur,

$$\frac{\partial U_{HH}}{\partial g_{(A)}} = \frac{\partial U_{HH}}{\partial M_L} = \frac{M_H(1-\beta)^2(N-M_H)^2}{[M_H(N-M_L) - \beta M_L(N-M_H)]^2} \tag{1.14}$$

The marginal benefits of the lighthouse (A) to this economy as a whole under a separating equilibrium regime are thus given by (1.13) + (1.14). We see that the marginal benefits are increasing in $g_{(A)}$, since $\frac{\partial^2 U_{HH}}{\partial M_L^2} > 0$.

Pooling equilibrium:- At this point, the marginal benefit of the lighthouse (A) to the low-ability entrepreneur is given by,

$$\frac{\partial U_{L\gamma}}{\partial g_{(A)}} = \frac{\partial U_{L\gamma}}{\partial M_L} = \frac{y}{N} - \frac{(1-\gamma)M_H}{[M_H - \gamma(M_H - M_L)]^2} \tag{1.15}$$

The marginal benefit of the lighthouse (A) at this point to the high-ability entrepreneur is given by,

$$\frac{\partial U_{H\gamma}}{\partial g_{(A)}} = \frac{\partial U_{H\gamma}}{\partial M_L} = \frac{\gamma M_H}{[M_H - \gamma(M_H - M_L)]^2} \tag{1.16}$$

(1.15) + (1.16) gives the total benefit of the lighthouse (A) to the economy under a pooling equilibrium regime. It is however decreasing in $g_{(A)}$ since both $\frac{\partial^2 U_{L\gamma}}{\partial M_L^2}$ and $\frac{\partial^2 U_{H\gamma}}{\partial M_L^2}$ are < 0.

Thus the marginal benefits of the lighthouse (A) are increasing under a separating equilibrium, and they are decreasing under a pooling equilibrium. We now have to show that at the switch point, defined by (1.12), the marginal benefits of the lighthouse (A) under the separating equilibrium exceed the marginal benefits under the pooling equilibrium. At the switch point given by (1.12), "assume true" that (1.13) + (1.14) > (1.15) + (1.16),

$$\Rightarrow \frac{M_H(1-\beta)^2(N-M_H)^2}{[M_H(N-M_L) - \beta M_L(N-M_H)]^2} > \frac{M_H(2\gamma - 1)}{[M_H - \gamma(M_H - M_L)]^2}$$

$$\Rightarrow \frac{(1-\beta)(N-M_H)}{[M_H(N-M_L) - \beta M_L(N-M_H)]} > \frac{\sqrt{(2\gamma - 1)}}{[M_H - \gamma(M_H - M_L)]}$$

Using the definitions, $c_H \equiv \frac{N(M_H - M_L)}{M_H(N-M_L) - \beta M_L(N-M_H)}$, and $\bar{r} \equiv \frac{N}{M_H - \gamma(M_H - M_L)}$, we have to show,

$$\frac{c_H(1-\beta)(N-M_H)}{N(M_H-M_L)} > \frac{\bar{r}\sqrt{2\gamma-1}}{N}$$

We now use the definition of the switch point given by (1.12), and we have,

$$M_H\bar{r} - N > \bar{r}\sqrt{2\gamma-1}(M_H-M_L)$$

$$\Rightarrow \bar{r}(M_H - \sqrt{2\gamma-1}(M_H-M_L) > N$$

Again using the definition of $\bar{r}$ given above, we have to show,

$$\frac{N(M_H-\sqrt{2\gamma-1}(M_H-M_L))}{M_H-\gamma(M_H-M_L)} > N$$

Since $\gamma < 1$ and $\gamma > \sqrt{2\gamma-1} > 0$ for all $\gamma \neq 1$, we therefore have,

$$\frac{(M_H-\sqrt{2\gamma-1}(M_H-M_L))}{M_H-\gamma(M_H-M_L)} > 1$$

The marginal benefit of the lighthouse (A) at the switch point is greater under the separating equilibrium compared to the pooling equilibrium■

VI - Proof of Proposition 6:

Separating Equilibrium: The marginal benefits of lighthouse (B) to the inefficient is given by,

$$\frac{\partial U_{LL}}{\partial g_{(B)}} = \frac{y}{N} \tag{1.17}$$

From the proof of Proposition 3, we get the marginal benefits of the lighthouse (B) to the efficient entrepreneurs,

$$\frac{\partial U_{HH}}{\partial g_{(B)}} = \frac{y}{N} + \frac{(1-\beta)}{N}c_H - (\frac{\partial c_H}{\partial M_L} + \frac{\partial c_H}{\partial M_H})[(1-\beta)(\frac{N-M_H}{N})]. \tag{1.18}$$

(1.17) + (1.18) give the marginal benefits of the lighthouse (B) to this economy as a whole under a separating equilibrium regime.

Pooling Equilibrium: The marginal benefits of lighthouse (B) to the inefficient under the pooling equilibrium is given by,

$$\frac{\partial U_{L\gamma}}{\partial g_{(B)}} = \frac{y}{N} - \frac{(1-\gamma)(M_H - M_L)}{[M_H - \gamma(M_H - M_L)]^2} \tag{1.19}$$

The marginal benefits of lighthouse (B) to the efficient under the pooling equilibrium is given by,

$$\frac{\partial U_{H\gamma}}{\partial g_{(B)}} = \frac{y}{N} + \frac{(\gamma)(M_H - M_L)}{[M_H - \gamma(M_H - M_L)]^2} \tag{1.20}$$

(1.19) + (1.20) gives the total benefit of the lighthouse (B) to the economy under a pooling equilibrium regime.

We first show that at the switch point, defined by (1.12), the marginal benefits of the lighthouse (B) under the separating equilibrium exceed the marginal benefits under the pooling equilibrium.

At the switch point (1.12), "assume true" that (1.17) + (1.18) > (1.19) + (1.20).

$$\Longrightarrow \frac{(1-\beta)(c_H)}{N} - \{\frac{\partial c_H}{\partial M_L} + \frac{\partial c_H}{\partial M_H}[\frac{(1-\beta)(N-M_H)}{N}]\} > \frac{(M_H - M_L)(2\gamma - 1)}{[M_H - \gamma(M_H - M_L)]^2}$$

Using (1.9) and (1.11), we can rewrite (1.17) + (1.18), and we therefore have to show,

$$\frac{(1-\beta)(c_H)}{N} + \{\frac{(1-\beta)^2(N-M_H)[M_H(N-M_H)-M_L(N-M_L)]}{[M_H(N-M_L)-\beta M_L(N-M_H)]^2}\}$$
$$> \frac{(M_H-M_L)(2\gamma-1)}{[M_H-\gamma(M_H-M_L)]^2}$$

Using the definition, $c_H \equiv \frac{N(M_H-M_L)}{M_H(N-M_L)-\beta M_L(N-M_H)}$, we have to show,

$$\frac{(1-\beta)(c_H)}{N} + \{\frac{(1-\beta)^2(c_H)^2(N-M_H)[M_H(N-M_H)-M_L(N-M_L)]}{[N(M_H-M_L)]^2}\}$$
$$> \frac{(M_H-M_L)(2\gamma-1)}{[M_H-\gamma(M_H-M_L)]^2}$$

$$\Rightarrow \frac{(1-\beta)(c_H)}{N(M_H-M_L)}\left\{\frac{(1-\beta)^2(c_H)^2(N-M_H)[N-M_H-M_L]}{[N(M_H-M_L)]^2}\right\} > \frac{(2\gamma-1)}{[M_H-\gamma(M_H-M_L)]^2}$$

Using the definition of $\bar{r} \equiv \frac{N}{M_H-\gamma(M_H-M_L)}$, we have to show,

$$\frac{(1-\beta)c_H[N(M_H-M_L)] + (1-\beta)^2(c_H)^2(N-M_H)[N-M_H-M_L]}{[N(M_H-M_L)]^2}\} > \frac{(2\gamma-1)\bar{r}^2}{N^2}$$

At the switch point(1.12), we have $(1-\beta)c_H = \frac{M_H\bar{r}-N}{N-M_H}$, we therefore have to show,

$$\frac{(M_H\bar{r}-N)}{N-M_H}[N(M_H-M_L)] + \frac{(M_H\bar{r}-N)^2}{N-M_H}[N-M_H-M_L] > \bar{r}^2(2\gamma-1)(M_H-M_L)^2$$

In the proof to proposition 5, we have shown that,

$$M_H\bar{r}-N > \bar{r}\sqrt{2\gamma-1}(M_H-M_L)$$

Therefore, in order to prove proposition 6, it suffices to show that,

$$\frac{(M_H\bar{r}-N)}{N-M_H}\{[N(M_H-M_L)] + (M_H\bar{r}-N)[N-M_H-M_L]\} > (M_H\bar{r}-N)^2$$

$$\Rightarrow N(M_H-M_L) + (M_H\bar{r}-N)(N-M_H) - (M_H\bar{r}-N)M_L > (M_H\bar{r}-N)(N-M_H)$$

$$\Rightarrow N(M_H-M_L) > (M_H\bar{r}-N)M_L$$

$$\Rightarrow NM_H > M_HM_L\bar{r}$$

$$\Rightarrow NM_H > NM_H\frac{M_L}{\gamma M_L+(1-\gamma)M_H}$$

Which is true because,

$$\frac{M_L}{\gamma M_L+(1-\gamma)M_H} < 1$$

It is thus proved that at the switch point, the Marginal benefits of the lighthouse (B) are greater under the separating equilibrium as compared to the pooling equilibrium ■

We now show that the Marginal benefits of the lighthouse (B) are decreasing both under the separating equilibrium and under the pooling equilibrium.

Separating Equilibrium: Refer (1.17) + (1.18) as MB_S, the Marginal Benefits of light-house (B) under the separating equilibrium.

$$MB_S = \frac{2y}{N} + \frac{(1-\beta)(c_H)}{N} + \{\frac{(1-\beta)^2(N-M_H)[M_H(N-M_H) - M_L(N-M_L)]}{[M_H(N-M_L) - \beta M_L(N-M_H)]^2}\} \tag{1.21}$$

We have to show that $\frac{\partial MB_S}{\partial g_{(B)}} = \frac{\partial MB_S}{\partial M_L} + \frac{\partial MB_S}{\partial M_H} < 0$.

To simplify the calculations, denote the term in the denominator, $[M_H(N-M_L) - \beta M_L(N-M_H)]$ as Φ and the term in the numerator $(1-\beta)^2(N-M_H)[M_H(N-M_H) - M_L(N-M_L)]$ as Ω.

Thus, MB_S can be written as,

$$MB_S = \frac{2y}{N} + \frac{(1-\beta)(c_H)}{N} + \{\frac{\Omega}{\Phi^2}\}$$

Which implies that,

$$\frac{\partial MB_S}{\partial M_L} = \frac{(1-\beta)}{N}\frac{\partial c_H}{\partial M_L} + \frac{[\Phi^2(1-\beta)^2(N-M_H)(2M_L - N) + \Omega 2\Phi(\beta(N-M_H) + M_H)]}{\Phi^4} \tag{1.22}$$

$$\frac{\partial MB_S}{\partial M_H} = \frac{(1-\beta)}{N}\frac{\partial c_H}{\partial M_H} + \frac{\{\Phi^2(1-\beta)^2[-(M_H(N-M_H) - M_L(N-M_L))]\}}{\Phi^4} + \frac{\{[(N-M_H)(N-2M_H)] - \Omega 2\Phi(N-M_L) + \beta M_L\}}{\Phi^4} \tag{1.23}$$

Adding (1.22) and (1.23), and collecting terms, we simplify the same in the following way:-

The coefficient of the term $\Phi^2(1-\beta)^2$ is,

$$\{\underbrace{(N-M_H)[(N-2M_H)-(N-2M_L)]}_{-} - \underbrace{[M_H(N-M_H) - M_L(N-M_L)]}_{+}\}$$

Which we see is less than zero. To show that, we see that the (+) term has been proved to be positive in proposition 3, and the (-) term is negative because $2M_H > 2M_L$.

Take the coefficient of the term $\Omega 2\Phi$ which is, $\{\underbrace{\beta(N-M_H)+M_H-(N-M_L)-\beta M_L}_{-}\}$.

This term is less than zero because, $\{(1-\beta)[M_H + M_L - N]\}$ is less than zero.

The third term to be considered is, $\{\frac{(1-\beta)}{N}[\frac{\partial c_H}{\partial M_H} + \frac{\partial c_H}{\partial M_L}]\}$. This term is less than zero because it follows from $[\frac{\partial c_H}{\partial M_L}] < 0$ and $[\frac{\partial c_H}{\partial M_H}] > 0$, and we showed in proposition 3 that,

$$|\frac{\partial c_H}{\partial M_L}| > |\frac{\partial c_H}{\partial M_H}|$$

And the denominator, $\Phi^4 > 0$. Thus it is shown that $\frac{\partial MB_S}{\partial g_{(B)}}$ is less than zero■

Pooling equilibrium: Denote (1.19) + (1.20) as MB_P, the marginal benefits of the lighthouse (B) under the pooling equilibrium. It is given as,

$$MB_P = \frac{2y}{N} + \frac{(M_H - M_L)(2\gamma - 1)}{[M_H - \gamma(M_H - M_L)]^2} \tag{1.24}$$

We see that $\frac{\partial MB_P}{\partial M_L} < 0$ and $\frac{\partial MB_P}{\partial M_H} < 0$. Therefore, $\frac{\partial MB_P}{\partial g_{(B)}}$ is less than zero ■

1.B Notes to Calculations:-

(I) The Perfect Information Equilibrium.

The problem is,

$$\underbrace{Max}_{\{r_i,c_i\}} U_{ii} = \frac{M_i}{N}(y - r_i) - (1 - \frac{M_i}{N})c_i - Z_i. \quad s.t. \quad \frac{M_i}{N} r_i + (1 - \frac{M_i}{N})\beta c_i = 1 \qquad (1.25)$$

Plugging the Zero Profit constraint of the bank into the Utility function and differentiating it w.r.t. c_i gives us,

$$\frac{\partial U_{ii}}{\partial c_i} = (1 - \frac{M_i}{N})(\beta - 1).$$

Which is negative, since β is less than one. Therefore, as per the Kuhn-Tucker conditions, $c_i = 0$. Putting this into the Zero Profit condition of the banks, we get the interest rates, $r_i = \frac{N}{M_i}$, as the reciprocal of the entrepreneur's ability.

(II) Effect of lighthouses on collateral: From Proposition 2, we can re-write c_H as,

$$c_H = \frac{N(M_H - M_L)}{M_H(N - M_L) - \beta M_L(N - M_H)}$$

$$\frac{\partial c_H}{\partial M_L} = \frac{N M_H(1-\beta)(M_H - N)}{[M_H(N - M_L) - \beta M_L(N - M_H)]^2}$$

We see that it is negative since $(M_H - N)$ is negative.

$$\frac{\partial c_H}{\partial M_H} = \frac{N M_L(1-\beta)(N - M_L)}{[M_H(N - M_L) - \beta M_L(N - M_H)]^2}$$

Which is positive.

Chapter 2

Public versus Private Signals in the Credit Market

2.1 Introduction

The level of investment in any economy, both domestic as well as foreign, depends to a large extent on the business environment in that economy. A country which has a poor implementation of laws and regulations governing its business contracts, a high level of bureaucratic inefficiency and corruption, poor quality of public services including infrastructure, political instability etc...will not attract a high level of private investment. An environment conducive to the flourishing of private initiatives needs to be fostered both by the institutions within an economy as well the public policies which shape it. The two taken together, may be said to constitute what is today called the "social infrastructure" of an economy (See Hall and Jones[45]).

In recent years, there has been an increasing availability of empirical data on this subject.[1] Based on such data, several cross-country studies find that those countries which rank low on this social infrastructure index (countries plagued by corruption, predatory business practices, and rent seeking activities) are also stuck with low levels of investment, lower productivity and lower levels of income and growth. Mauro[56], for example, uses a data set consisting of subjective indices of bureaucratic honesty and efficiency to find a negative impact of corruption on investment levels. According to him, if Bangladesh were to achieve a one standard deviation increase in its bureaucratic efficiency (which would take to the level of bureaucratic efficiency in Uruguay), its investment rate would rise by five percentage points and its yearly GDP growth would rise by half a percentage point. Hall and Jones[45], conclude that countries which achieve high rates of investment in physical and human capital and thereby high rates of productivity, consistently score high on the social infrastructure index. Recent studies in the transition economies[25], also indicate that wide spread predation and insecure property rights have depressed capital accumulation in these countries in all its dimensions. And lastly, Shang-Jin Wei[68], arrives at a similar conclusion with respect to foreign direct investments in the developing economies.

Based on the above empirical results, the object of this paper is to provide a possible "micro" link between social infrastructure indicators and investment decisions. I shall not go into the theoretical reasons explaining corruption or bribery undertaken by firms (See Bardhan[22] for an excellent review), but given that varying levels of social infrastructure

[1] The latest being an extensive survey by the World Bank Group [70] of some 10,000 firms in 80 countries between late 1999 and mid-2000, on the business environment facing firms, called the World Business Environment Survey, (WBES), 2000.

exist (which differ from country to country, or even differ across regions within the same country), I would like to explain their relation to the borrowing and investment decisions of firms.

A common explanation which is given is that investing in such regions is generally risky. This generalization is trivial, when we consider that lenders (banks) can devise contracts which can separate the risky projects from the not so risky. Therefore, the question I will be trying to answer is that why would a lender (presumably, a bank in this case) look to these economy-wide indicators instead of firm-specific indicators in taking its lending decisions?

The mainstay of the explanation will be the existence of asymmetric information in the credit market. I essentially build on two models, (a) Hellwig[46], which takes into consideration ex-ante, pre-contractual adverse selection problems in a three stage dynamic game being played between the lenders and borrowers in the credit market, and (b) Aghion and Bolton[1], which deals with post-contractual moral hazard issues in the credit market. Earlier models have shown how imperfect information in the credit market may give rise to credit rationing [65]. However, increasing the contract space of the banks to include both the interest and the collateral allowed for the possibility of the banks using collateral as a self-selection device and avoiding the problem of adverse selection[16]. In this paper, I allow banks to simultaneously choose interest rates and collateral requirements, but in addition to the pre-contractual information asymmetry, along the lines of Stiglitz and Weiss [?], I add another level of information asymmetry in the form of a post-contractual, moral hazard problem.

This paper then shows that due to this interaction between selection and incentive effects, private signalling loses its relevance as a self-selection device. *Lenders would then* increasingly resort to public signals like social infrastructure indicators. *It is through this* link that such public indicators which define the business environment of a firm affect their investment decisions. I then go on to show that credit rationing could be more severe in economies having a poor social-infrastructure. Thus, in a simple theoretical model which explicitly takes into account a parameter of social infrastructure (the possibility that because of poor implementation of laws, corruption, need for 'irregular payments' to bureaucrats etc... firms do not earn their full revenue, which they would under ideal circumstances), I show how economies ranking low on the corruption index have higher levels of investment. This would also explain, for example, given the global nature of investment portfolios, there is an increasing emphasis on collecting and understanding country risk measures by institutional investors.

The paper is organized as follows, section 2 introduces the model. Section 3 establishes the key result of the existence of a pooling equilibrium in the credit market. Section 4 discusses the effect of social infrastructure on this equilibrium, and the conclusion is given in section 5.

2.2 Model

Agents : Identical agents who are endowed with 1 unit of labor (l), which they supply inelastically. They are also endowed with wealth ($w < 1$), which can be deposited in a bank, or used as collateral to obtain loans from the bank. The agents are risk-neutral, live for 2 periods and they produce in the first period and consume in the second. These agents have 2 choices: to be workers in a routine activity which only requires labor (and thus deposit w in the banks), or to undertake an entrepreneurial project which requires them to combine 1 unit of labor with 1 unit of capital. Workers get a deterministic return Z. Potential entrepreneurs have to borrow 1 unit of capital in order to undertake the project. More about the entrepreneurial project will be said below.

Banks : Banks in this economy are risk-neutral and act as Betrand Competitors in a market where they obtain elastically supplied funds. We normalize the gross deposit rate at which the banks obtain these funds to be one. Since we assume banks to be Betrand competitors, they make zero profits in equilibrium on the projects they lend.

Projects : The returns from the project are Uncertain. The uncertainty in this project stems from two sources,

Ex-Ante - The project has a success probability of p. This is however not known ex-ante either to the potential entrepreneur or to the banker. What the entrepreneur does know ex-ante is the return from the project, if it is successful. It is in determining the returns from a successful project that this model takes into the social infrastructure of the economy. In an ideal situation, a successful project will yield the entrepreneur its full yield (Y_F). However, firms lose revenue in a business environment which is constrictive and predatory. I base this observation on the World Bank Business Environment Survey, 2000 (WBES). Respondents in this survey were asked if it was common for firms "in their line of business to have to pay some irregular 'additional payments' to get things done?" In South Asia and Developing East Asia more than 60% of the firms said this was always, mostly or frequently the case. In Africa, more than half of the firms reported that such payments were at least frequently required. In the transition economies of

Central and Eastern Europe, around a third of the firms provided such responses. *Only in the* OECD countries and the industrialized East Asia could this response be *described* as rare - around 12% of the firms. To gauge the actual impact of such *payments*, WBES enquired about the total percentage of revenues paid as "unofficial payments" to public officials. These payments are the highest in the transition economies of Eastern and Central Europe at 5.5% of revenues, in South Asia (which consists of India, Pakistan *and Bangladesh) it was* 5%, while in developing East Asia, it was 4.6% of the total *revenues. In contrast, 86.3%* of the firms in the newly industrialized East Asia, and 83% *of the firms in the OECD* countries reported paying 0% of their revenues in bribes [5].

Therefore in *this* model, let the proportion of firms who have to suffer a lower yield on account of such payments be γ. Let this lower yield be denoted Y_L. (Firms could potentially suffer a range of low yields on this project on account of such payments, but I summarize it to be Y_L, and $Y_L < Y_F$). Since such payments are unofficial, whether their yield is Y_F or Y_L is the private information of the firms. γ is thus an indicator of social infrastructure, which is public information. Higher the γ, higher is the *proportion* of firms who have to lose revenue on account of factors such as corruption, *bribery, lobbying* for award of government contracts, payments for procurement of public services etc...and greater is the size of this 'shadow' or unofficial economy.[2]

[2] This assumption implies that firms who choose to make such payments are not engaged in 'predation' (where predation includes rent-seeking and dupe activities [25]). Therefore, it is very different from the Murphy, Schleifer and Vishny hypothesis [6] where firms choose between productive and predatory activities depending upon the returns guaranteed to them by the system. Here we have a single productive project, but on account of the poor social infrastructure, some firms have to make illegal payments to carry out the project. This assumption is closer to the Grossman and Kim [?] hypothesis where some

Ex-post : In the post-contractual ex-post scenario, the success probability (p) gets determined. p is an indicator of the effort put in by both types of entrepreneurs, once they secure a loan contract and have to implement the project. It is optimally chosen only after acceptance of the loan contract. Since the probability of success p is an indication of the the individual's effort, there is an effort cost c(p). Following Aghion and Bolton[1], we assume a uniform convex cost function across individuals,

A 4 $c(p) = \frac{p^2}{2}$.

The project is high yielding. We explicitly assume 'high yielding' to be,

A 5 $Y_i - 1 > Z, \quad \forall i \in \{F, L\}$. *The expected value of the net returns from the project exceed the opportunity cost of the project to all agents.*

Thus there exist incentives for all agents to undertake the project.

2.3 Capital Market Equilibrium

Taking into consideration, this two-layered information asymmetry, the capital market equilibrium is obtained in the following way,

The optimal loan contract: Assume there exists only a standard debt contract for investing funds (issuing equity is costly). As in the model of Bester [16], banks offer a loan contract consisting of a pair $\langle r, c\rangle$ where r is the gross interest rate charged and c

firms are moral and would not engage in corrupt practices, and some firms are amoral and would engage in corruption. In this model however, the morality of firms is not fixed or given, but it is a function of the parameter γ, which is determined by the institutions and public policies of an economy, and thereby amenable to change.

is the collateral that the borrowers are willing to put up. We also make the following additional assumption,

A 6 *Collateralizing is costly. Collateral of value c_i to the borrower gives to the bank a value of βc_i, in the event the borrower defaults, where $\beta \in (0,1)$.*[3]

As in Hellwig [46], the a 3 stage sequential game is being played in the credit market. This game explicitly takes into account dynamic reactions of borrowers. The optimal loan contract can be seen as a solution to a 3 stage game,

Stage I: Banks offer contracts $\langle r_i, c_i \rangle$.

Stage II: Given the contracts the borrower i chooses p such that it maximizes her expected revenue from the project net of (a) repayment cost (b) effort costs. The borrower chooses the contract most attractive to him. He can choose only a single contract.

Stage III : The banks may accept or reject the loan applications they have recieved in Stage II.

The optimal contract $\langle \hat{r}_i, \hat{c}_i \rangle$; $\forall i$ = H, L is a set of contract offers which determine the equilibrium in this 3 stage game. i.e. given $\langle \hat{r}_i, \hat{c}_i \rangle$ $\forall i$ = H, L

- Banks make zero profits on each contract and
- No bank has the incentive to offer a different loan contract than the ones offered.

Since this game is sequential, the equilibrium considered will be the sub-game perfect or sequential equilibrium. The usual condition that each agent's strategy be the best response to the other agent's strategies is applied not only to the overall game, but

[3] The assumption of the bank not being able to realize the full value for the collateral in case of default by the borrower, apart from having real world justifications is also crucial for the existence of equilibrium in a risk neutral environment. See Clemenz [26].

to every decision node in the game tree, regardless of whether this node is reached in equilibrium. We define U_{ij} to be the utility to agent of type i applying for a loan contract meant for type j.

2.3.1 Equilibrium when the banks can distinguish types

As a benchmark, we solve first the case when banks can distinguish between types. The banks are aware of the illegal payments that have to be made by firms, i.e they are aware of whether the revenue of the firms is Y_F or Y_L. This is the solution in the absence of adverse selection, when banks have to tackle only the post contractual moral hazard problem. They are not aware of the effort that will be put in by the borrowers after they get the contract. The problem for the entrepreneur is,

$\underbrace{Max}_{p_i,r_i,c_i} U_{ii} = p_i(Y_i - r_i) - (1 - p_i)c_i - \frac{p_i^2}{2}$ s.t.

(i) the Zero profit constraint for the banks: $R_b \equiv p_i r_i + (1 - p_i)\beta c_i = 1$.

(ii) the self selection constraints $U_{ii} \geq U_{ij}$.

(iii) The Individual Rationality constraint $U_{ii} > Z$.

In the full-information case, the self-selection constraints do not bind. Therefore, the borrower solves

$$\begin{aligned} \underbrace{Max}_{p_i,r_i,c_i} &: \quad p_i(y_i - r_i) - (1 - p_i)c_i - \frac{p_i^2}{2} \\ s.t. \quad R_b &\equiv \quad p_i^* r_i + (1 - p_i^*)\beta c_i = 1 \\ U_{ii}^* &= \quad Z \end{aligned}$$

Where p_i^* refers to the equilibrium choice of effort by the entrepreneur, and U_{ii}^* refers to the equilibrium level of utility, once the effort has been chosen. Before we give the full information solution we see that the equilibrium effort level p_i^*, given the interest rate r_i and collateral c_i has to satisfy the following conditions,

$$p_i^* = y_i - r_i + c_i \quad where \quad 0 < p_i^* \leq 1. \quad \forall i. \tag{2.1}$$

$$U_{ii}^* \equiv \frac{(p_i^*)^2}{2} - c_i = Z. \quad \forall i. \tag{2.2}$$

(1) is the condition on the probabilities and (2) is the individual rationality (IR) condition which determines the entry of the potential entrepreneur. We see that the equilibrium level of effort, or the probability of success of the project is dependent not only on terms of the contract, but also the efficiency of the social infrastructure which determines Y_i. So, $p = p(Y_i, r_i, c_i)$. The above formulation thus enables to get a simple probability function, where the probability of success (effort) is positively related to the business environment within which firms in the economy have to carry out their business projects, the collateral which they are able to post, and negatively related to the gross interest rate which they have to pay on the loan. The full information solution is

$$c_i = w. \tag{2.3}$$

$$r_i = \frac{1}{2}\{Y_i + (1+\beta)w - [(Y_i + (1+\beta)w)^2 + 4(\beta w(1 - Y_i - w) - 1)]^{\frac{1}{2}}\}. \tag{2.4}$$

There are two things to note about this Full Information solution:

(i) Though the maximization problem involves solving 3 unknowns given a system of 2 equations - one of the unknowns, namely c_i, gets determined by the nature of the game being played in the credit market. The banks would prefer to take maximum collateral from all agents ($c_i = w$). The reason being that the expected returns of the bank R_b

increases with the collateral posted, viz. $\frac{\partial R_b}{\partial c_i} > 0$, but $\frac{\partial R_b}{\partial r_i}$ is ambiguous. Since,

$$\frac{\partial R_b}{\partial r_i} = p_i + (r_i - \beta c_i)\frac{\partial p_i}{\partial r_i} \qquad where \quad \frac{\partial p_i}{\partial r_i} < 0 \tag{2.5}$$

The effort that the entrepreneurs put in, which defines the success probability (p) is negatively related to r, but positively related to the collateral, c. Thus the banks would require the borrowers to use *all their* wealth as collateral, and determine the interest rate subject to this. Loan applications with any other amount of collateral would be rejected by the bank in Stage III and knowing this, in equilibrium no such application would be forthcoming. The solution to r_i in (4) is then a solution to a quadratic equation. It is obtained by plugging p_i^* and $c_i = w$ in the the Zero profit condition of the bank, given in (i) [4].

(ii) When the banks can separate out the types, individual contracts can be designed by the banks, such that corruption can be weeded out to an extent. As we see below, firms who engage in corrupt practices are charged a higher interest rate, as compared to the more honest firms.

$$\frac{\partial r_i}{\partial Y_i} < 0 \quad \Rightarrow \quad r_F < r_L \tag{2.6}$$

[4]We take the root with the lesser value. Both the lenders and the borrowers know the rules of the game, and if there exists more than one solution, the lowest among these (viz. the one associated with the higher effort p) will be compatible with pareto efficiency.

2.3.2 Asymmetric information equilibrium in the presence of both adverse selection and moral hazard:

The full information equilibrium does give us a clue into the equilibrium that we will reach when the banks are unaware of the revenues of the firms who apply for loans. In considering the separating equilibrium as a solution, we see the following,

In the r-c plane, totally differentiate $U_{ii}^{*} = (\frac{(p^{*})^{2}}{2} - c_i)$ to get in the context of borrowers,

$$\frac{dr_i}{dc_i} = \frac{p^{*} - 1}{p^{*}} < 0. \tag{2.7}$$

(7) establishes that the indifference curves of the borrowers in the r-c space are downward sloping, and satisfy the single crossing property. viz. the borrower who expects to make unofficial payments and get a lower return Y_L, has a lower MRS as compared to the borrower who expects his full yield from the project Y_F. For a small reduction in the interest rates, the latter is willing to post more collateral as compared to the former.

However, the other condition for the existence of a separating equilibrium is that the zero-profit curves for the banks should be flatter than the indifference curves of the borrowers. We show that this condition cannot be satisfied and therefore, the types cannot be sorted out by the banks. The contracts cannot be self selected and we have the following, [Proof in the appendix].

T1 *Non-existence of a separating equilibrium in the credit market*

When collateral is also used to monitor the effort put in by heterogenous borrowers after a loan contract is accepted, collateral ceases to be a screening device to screen out the efficient borrowers from the inefficient. Technically **T1** establishes that in this model, the zero-profit curves of the banks are steeper than the indifference curves of the borrowers, which violates the necessary condition for the existence of a separating equilibrium. What this means is that in spite of the the bank having an additional instrument in the form of collateral, it still cannot have perfect control. It is not possible for the banks to separate out the corrupt firms from the non-corrupt firms. Collateral, in this case, cannot be used as a self-selection device by the borrowers. The intuition behind this result is that collateral is akin to "monitoring costs" in this model. By making the borrowers put in all their wealth as collateral the banks are ensuring that the entrepreneurs of both types put in maximum effort after the contract is accepted. By taking collateral, banks try to solve the moral hazard issues which arise in the credit market.

Thus, in this model where both adverse selection and incentive effects are considered simultaneously, existence of private signalling in a separating equilibrium may not be possible. Collateral is used by banks to solve moral hazard problems - it does not serve as a screening device to screen out the corrupt firms from the non-corrupt. The only equilibrium which exists in this economy is the complete pooling equilibrium, where only one type of a bank contract is offered to everybody.

Pooling Equilibrium : The solution to this pooling equilibrium is given by

$$c = w.$$

$$r = \frac{1}{2}\{\hat{Y} + (1+\beta)w - [(\hat{Y} + (1+\beta)w)^2 + 4(\beta w(1 - \hat{Y} - w) - 1)]^{\frac{1}{2}}\}.$$

where $\hat{Y} \equiv Y_F - \gamma(Y_F - Y_L)$.

Once we have established that no separating equilibrium can exist, the solution to the pooling equilibrium follows the same logic as given in the Full information case (3) and (4). However, since the banks are not aware of the actual yields that the entrepreneurs get from the project, they have to offer the contract on the basis of the average yield that the perceive in the economy, depending upon the γ, or the social infrastructure parameter. So, $\hat{Y}$ is the average productivity in the economy as perceived by the banks. The reason for taking maximum collateral ($c = w$) remains the same as given in the Full information case, where since loan applications can be rejected by the banks in Stage III, therefore in equilibrium, no applications with $c < w$ will be forthcoming. For ease of computation WLOG[5] assume $\beta = 1$. The pooling equilibrium is then given by

$$c = w. \quad (2.8)$$

$$r = \frac{1}{2}\{\hat{Y} + 2w - [\hat{Y}^2 + 4w - 4]^{\frac{1}{2}}\}. \quad (2.9)$$

$\hat{Y}$, the average yield of the project in the economy, is defined as before.

2.4 Social Infrastructure and Credit Rationing

We now introduce another form of heterogeneity in the model. We assume that individuals differ in wealth (w). This heterogeneity is observable and differences in the wealth of borrowers is public knowledge. We assume that the wealth is distributed as per a

[5] $\beta < 1$ is the necessary condition for $\exists$ of a separating equilibrium in a risk neutral environment. Proof of T1 shows that even when $\beta \in (\beta^*, 1)$ a pooling equilibrium pareto dominates. Therefore we can assume $\beta = 1$, WLOG.

c.d.f $F(w)$. We retain the assumption of all wealth being used as Collateral in borrowing. Lenders can now classify borrowers as per risk, on the basis of an observable indicator, the wealth they have to post as collateral. Given that collateral is positively associated with effort (and negatively associated with risk), the banks classify the poor borrowers to be riskier than the rich borrowers. This classification determines the interest rates that will be charged to each class. We also get the familiar result[10] that the interest rates in this economy are negatively related to the wealth that can be posted as collateral. There exists credit rationing in this economy, such that all borrowers below the critical wealth group w^* do not have access to credit. We can show the following, [Proof in the appendix]:

> **P1** *In a pooling equilibrium in the credit market, the social infrastructure of the economy determines the critical w^*, which defines the extent of credit rationing in this economy.*

The intuition is straight forward - given the social infrastructure parameter γ of an economy, collateral is used then in monitoring the effort exerted by the entrepreneurs in such an economy. Entrepreneurs posting more collateral are seen to be safer risks, irrespective of their actual returns from the project and are charged lower interest rates. (7) also determines the critical wealth group w^* (calculation in the appendix), below which no lending will be done by the banks. All borrowers having wealth less than w^*, irrespective of their actual yield from the project, will be rationed from the credit market. This will occur in spite of the fact that lending is socially optimal. It is perceived by the banks that lending to this group does not make the banks break-even at any interest rate.

w^* is a function of the social infrastructure index of the economy γ. Higher the value of this parameter, greater will be the proportion of the population that will be barred from the credit market. A high γ means that a greater proportion of firms have to indulge in bribery and other unofficial payments - this indicates the quality of the social infrastructure in the economy. Therefore, given a distribution of wealth in the economy, the extent of credit rationing is greater when the social infrastructure of the economy is poor (γ is high). The banks will then play safe by lending only to the wealthier groups having sufficient collateral. This is shown in the diagram below where the interest rates in the economy are negatively related to the amount of wealth posted as collateral, given the economy's social infrastructure indicator present in γ. With a decrease in γ, and thereby an increase in $\hat{Y}$, there is a shift of this curve to the left. For a given distribution

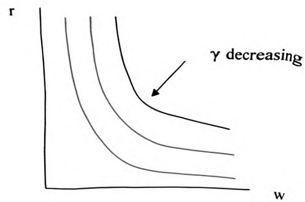


Figure 5: Infrastructure and Credit Rationing

of wealth, lower the social infrastructure parameter γ, both the cost of funds r and w^*, the critical wealth level below which borrowers are barred from borrowing, is reduced. The extent of credit rationing of borrowers below a w^* thus depends upon the social infrastructure indicator of the economy.

2.4.1 Effect of a decrease in the parameter γ

From the section above, it is now easy to conclude about the effects of policy driven initiatives which reduce γ, the proportion of firms who have to resort to unofficial payments and corruption, viz. the size of the 'shadow' or unofficial economy.

(a) There are the "price effects" through the interest rates. We see that $\frac{\partial r}{\partial \gamma} > 0$. So with a decrease in the parameter γ, the cost of borrowing in the economy is reduced. Therefore, this result suggests that economies ranking low on the corruption index would also be able to obtain funds at cheaper rates than those economies which are plagued by corruption and rent seeking activities.

(b) There is also an "entry" effect, related to the extent of credit rationing in this economy. With the decrease in γ, the cut off w^* is reduced, since $\frac{\partial w^*}{\partial \gamma} > 0$. While credit rationing is a possible outcome in many models of asymmetric information, this possibility is made severe in the presence of corruption, inefficiencies in implementation of laws, and all those factors which hamper the firms from conducting their businesses. Therefore policy initiatives to reduce γ will ameliorate the degree of credit rationing in such economies.

These results are important because they suggest that as asymmetric information models about the credit market are made more realistic to include a range of information asymmetries, the scope for private signalling is reduced. Public signals in the form of laws and regulations, infrastructure, and the quality of bureaucratic services will then be increasingly used to determine the extent of investment in an economy. The relevance of such public signals lies in the fact that in an imperfectly informed world, they expand the information set that is available to the economy.

2.5 Conclusion

The aim of this paper was to provide one among the many possible explanations to common query: What are the reasons for investment levels being higher in a country like Singapore as compared to a country like Bangladesh? I have tried to explain this within the context of asymmetric information in the credit market. It is fairly clear that as asymmetric models are made more complex to include both adverse selection and moral hazard, the possibility a pooling equilibrium and thereby credit rationing in equilibrium increases. In this paper I also show that in the presence of such a multi-layered asymmetric information structure, private signals can get obfuscated and there will be a greater reliance on public signals. An efficient legal and judicial system, a smoothly functioning bureaucracy, good quality of public services, an environment where firms are not compelled to make "irregular payments" to get their work done, are all 'public' indicators which underlie their smooth functioning. It is factors like these which are increasingly defining the lending and investment decisions of today. Singapore is able to publicly signal its intentions to investors. The same cannot be said about Bangladesh.

2.A Appendix:

I. Proof of T1:

The slope of the indifference curves in the r - c plane is given by totally differentiating U_{ii}, which is given as follows,

$$U_{ii} = \frac{(Y_i - r_i + c_i)^2}{2} - c_i$$

$$\Rightarrow \frac{dr_i}{dc_{i\,(borrowers)}} = \frac{(Y_i - r_i + c_i) - 1}{(Y_i - r_i + c_i)} < 0.$$

Since $(Y_i - r_i + c_i)$, we know is the equilibrium probability of success of the project denoted as p^*, and $p^* < 1$.

The isorevenue curves of the banks is given by

$$R_b = p^* r_i + (1 - P^*)\beta c_i$$

$$\frac{dr}{dc_{(banks)}} = \frac{-\frac{\partial R_b}{\partial c}}{\frac{\partial R_b}{\partial r}}$$

$$\frac{\partial R_b}{\partial c} = \frac{\partial p^*}{\partial c}(r_i - \beta c_i) + (1 - p^*)\beta > 0 \quad \forall \beta \in (0,1).$$

$$\frac{\partial R_b}{\partial r} = \frac{\partial p^*}{\partial r}(r_i - \beta c_i) + p^* \gtrless 0 \quad since \quad \frac{\partial p^*}{\partial r} < 0.$$

$$\frac{\partial R_b}{\partial r} > 0 \quad iff \quad (r_i - \beta c_i) < p^*$$

$$iff \quad 1 > \beta > \frac{r_i - p^*}{c_i} > 0$$

Which puts very stringent conditions on the returns from the project Y_i, viz.

$$2(r_i - c_i) < Y_i < (2r_i - c_i) \tag{2.10}$$

Given the above, there is an additional condition on β,

$$1 > \beta > \frac{r_i - p^*}{c_i} \equiv \beta^* \tag{2.11}$$

Given the two conditions on Y_i and β above, we will have the isorevenue curve of the banks negative in the r-c space.

$$\frac{dr}{dc}_{(banks)} = -\frac{[(1-p^*)\beta + (r_i - \beta c_i)]}{p^* - (r_i - \beta c_i)} \tag{2.12}$$

Given that both the indifference curves of borrowers and the isorevenue curves of the banks are negative in the r-c space, the necessary condition for the existence of a separating equilibrium is that

$$\left|\frac{dr}{dc}\right|_{(banks)} < \left|\frac{dr}{dc}\right|_{(borrowers)} \tag{2.13}$$

i.e. the indifference curves of the borrowers should be steeper in the r-c space than the isorevenue curves of the banks.

$$\begin{aligned}\left|\frac{dr}{dc}\right|_{(borrowers)} &= \frac{1-p^*}{p^*}\\ \left|\frac{dr}{dc}\right|_{(banks)} &= \frac{\beta(1-p^*) + (r_i - \beta c_i)}{p^* - (r_i - \beta c_i)}\end{aligned}$$

We now show that 2.13 above cannot be satisfied. Taking the denominators of the two terms, we see that $p^* - (r_i - \beta c_i) < p^*$. Therefore, the necessary condition for the existence of a separating equilibrium depends upon the value of the numerators in both the terms. Which is,

$$\begin{aligned}\beta(1-p^*) + r_i - \beta c_i &< 1 - p^*\\ \beta &< \frac{(1-p^*) - r_i}{(1-p^*) - c_i}\end{aligned}$$

We know $(1-p^*) - r_i < 0$, since r_i is the gross interest rate and therefore > 1. Therefore taking the denominator of the RHS, we now have to consider two possibilities, $(1-p^*) -$

$c_i \gtrless 0.$

$$if \quad (1-p^*) - c_i > 0 \quad \Longrightarrow \quad \beta < 0$$

$$if \quad (1-p^*) - c_i < 0 \quad \Longrightarrow \quad \beta > 1 \quad (since \quad |1 - p_i - r_i| > |1 - p_i - c_i|)$$

Which is a contradiction to our assumption A 3. Therefore, even if the isorevenue curves of the bank turn out to be negative in the r-c space, a separating equilibrium cannot exist as they turn out to be steeper than the indifference curves of the borrowers ■

II. Proof of P1 :

$$\frac{\partial r}{\partial w} = 1 - \frac{1}{(\hat{Y} + 4w - 4)^{\frac{1}{2}}}. \tag{2.14}$$

In order to prove that $\frac{\partial r}{\partial w} < 0$, we have to show the following,

$$0 < \hat{Y} + 4w - 4 < 1. \tag{2.15}$$

Note that from the definition of r given in (7), we have

$$\hat{Y} + 4w - 4 \equiv \hat{Y} - 2(r - w).$$

$\hat{Y} - 2(r - w) > 0$, which follows from the proof of T1. And it follows from the definition of p^* that $0 < \hat{Y} + 4w - 4 < 1$. So, we see that,

$$\frac{\partial r}{\partial w} < 0.$$

Given a distribution of wealth F(w), there is no solution to (7) when

$$\hat{Y} + 4w - 4 \leqslant 0. \tag{2.16}$$

This defines the cut off w^* for which there is no solution to (7), and it is given by,

$$w^* \equiv 1 - \frac{Y_F - \gamma(Y_F - Y_L)}{4} \tag{2.17}$$

What this means is that that below a collateral level of w^*, banks are not willing to lend since they cannot break even on such contracts. Therefore, all agents with wealth $\in [0, w^*]$ will not be able to borrow even if they want to. As we see, $\frac{\partial w^*}{\partial \gamma} > 0$. Therefore the critical point of credit rationing gets lower with a reduction in the parameter γ $\blacksquare$

Chapter 3

Infrastructure and Financial Constraints – what do firms have to say?

3.1 Introduction

That there exist strong links between infrastructure provision and productivity is an established fact. However, the precise linkages between infrastructure provision and productivity are still open to debate. Much research in the recent years has been devoted to estimating the productivity of infrastructure investments. The emphasis of most of these macro-econometric studies (using both time series and cross section data) has been on arriving at "credible" measures of the impact of infrastructure on economic productivity and growth.[1]

Most time-series studies in the US and other developed economies suggest startlingly high rates of return on infrastructure development. This is seen to be an overestimation in many cases (Gramlich, 1994). Many studies report public sector investment as having substantially greater impact on private sector output than private sector investment. The reasons for this overestimation could be two-fold: (a) Missing

[1] The Box 1.1 in the World Development Report, 1994 does a succinct summary of the various estimates.

factor explaining trends: There could be a common factor that causes changes in both infrastructure and the output that needs to be included. Gramlich in his review essay cited above suggests that gasoline prices which led to both, a reduced demand for tractors/trucks and thereby a reduced demand for highways and to a lower output in the 1970's should be factored into this link. (b) Reverse Causality: Another important concern has been endogeneity and the direction of causality between infrastructure and output. While infrastructure may affect productivity and output, economic growth can also shape the demand/supply of infrastructure services which could lead to the overestimation of the returns to infrastructure. While common trend is a potent problem in the studies which use time-series data, the cross section studies do arrive at more sensible measures ranging from an implied rate of return equal to the rate of return on private investment (on the higher side) to zero (on the lower side). But cross section data also is not immune from the problem of reverse causality. In addition, in the cross section studies heterogeneity is another problem. There could be an overstating of infrastructure impacts by confounding intrinsic state/nation productivity differences with the variation in infrastructure capital. Taking state level data for example, because prosperous states would tend to spend more on public capital, there will be a positive correlation between state specific effects and public sector capital (Holtz-Eaken, 1994). However neither the time series not the cross sectional studies explain the mechanisms through which infrastructure affects growth. Unless such "micro" links between infrastructure and growth are uncovered – it will be difficult to understand the complex aggregate relationship. Thus these results suggest two kinds of agendas for future research in this area: (a) detangling the endogeneity and heterogeneity issues econometrically using more disaggregate data and (b) making the microeconomic linkages between provision of infrastructure and the nature of the production process more precise. It will be crucial to know how other variables that affect growth work through infrastructure.

This paper tries to fill the gap as regards agenda (b) by using disaggregated nation wide firm level data based on the World Bank Business Environment Survey (WBES, 2000). It tries to show how infrastructure can crucially affect the ease with which firms can obtain funds from the capital market. The theoretical underpinning of this link is based on the analysis of public inputs in the context of asymmetric information, where infrastructure provision is seen to reduce the heterogeneity among firms. This reduction in heterogeneity has a crucial impact on the capital market, which is besieged by imperfect information. Infrastructure is seen there to reduce the costs of asymmetric information and improve the equilibrium in the capital market.

Regarding empirical studies on these infrastructure-financial sector linkages, there have been some cross-country studies bringing out the link between infrastructure and the financial sector. Cross-national studies considering the impact of infrastructure on differences in the FDI flows (Globerman / Shapiro, 2002) find that FDI inflows respond positively to good governance infrastructure and human capital. In a more detailed study regarding physical infrastructure and capital flows, Mathias Hoffman (2003) shows that differences in information and transport technology is able to explain cross country variations in FDI and debt positions of countries . Sectoral studies focusing on rural infrastructure's impact on the local economy in certain developing economies have revealed more about the infrastructure – financial sector linkages. Studying data over time from 85 districts in 13 Indian states, researchers found that improved communications (through roads) lowered the banks' costs of doing business. Banks expanded lending to farmers and thereby increased farm output (Binswanger, et el, 1994).

This study differs from the above in several ways. It uses firm-level data to capture the link between infrastructure provision and financial constraints. The data is qualitative, based on the responses given by firms to questions regarding the difficulties faced by them with respect to infrastructure provision and obtaining finance. Using this survey data from some 10,000 firms spread across 80 countries (The World Bank Business Environment Survey, 2000) this study tries to capture the nexus between these infrastructural and financial constraints facing firms. Using both Ordered logit and Ordered Probit estimates, it concludes that taking care of all region specific and firm specific differences, firms facing high infrastructural constraints are most likely to face high financial constraints as well. More specifically, this link is seen to be stronger in the case of (i) firms in low income, developing countries as compared to high income developed countries (ii) smaller sized firms as compared to the larger firms.

3.2 Data and Methodology

The World Business Environment Survey (WBES 2000) was administered by the World Bank in roughly a parallel fashion to enterprises in 80 countries and one territory throughout the world, as basis for making regional comparisons of investment climate and the business environment conditions. The World Business Environment Survey (WBES 2000) is a survey of over 10,000 firms in 80 countries that examines a wide range of interactions between firms and the state. Based on face-to-face interviews with firm managers and owners in late 1999 and early 2000, the WBES generated measurements in such areas as corruption, judiciary, lobbying, investment climate and the quality of the business environment. This survey thus tried to capture the firms' perceptions of key constraints in the business environment. Among the constraints faced by the firms were those relating to (a) Finance and (b) Quality of public services. Finance was the second leading constraint for most firms. At least 50% of the firms in all developing regions cited financing as a serious constraint, only 40% of the firms in OECD countries found it to be so. Finance as a constraint was more important to the small and medium enterprises in the survey than to the large enterprises. Another key dimension of the business environment was the quality of public services. WBES explored both the overall efficiency of the government in delivering services and the quality of individual services. Nearly two thirds of the firms in Central Europe, Latin America and CIS countries and nearly 60% of the firms in South Asia report that government is inefficient in delivering services.

To get an idea of this nexus, table 1 shows the correlation between financial constraints and infrastructure constraints. Taking the subset of private, domestic firms (state owned firms and foreign firms were dropped out) it is seen that while 35% of firms facing no infrastructural constraints reported they had no financial constraints too, while only 7% of the firms facing major infrastructural constraints reported that they no financial constraints. A test of the null hypothesis using Kendall's tau-b that financial constraints and infrastructural constraints are independent was rejected.[2] The Kendall's tau-b was more significant when this test was done disaggregating the data by firm size.

[2] Kendall's tau-b = 0.2441; Kendall's score = 3654854; SE of score = 157568.200 (corrected for ties); Test of Ho: gcf and infr are independent; Prob > |z| = 0.0000 (continuity corrected)

Small sized firms showed a stronger correlation between infrastructure and financial constraints as compared to the medium sized or larger firms.

Table 1: Correlation between Financial constraints and Infrastructure constraints

general constraint - finance	general constraint - infrastructure: no obstac	minor obs	moderate	major obs
no obstacle	671	218	146	77
minor obstacle	319	401	254	109
moderate obstacle	414	579	524	262
major obstacle	530	619	650	633
Total	1934	1817	1574	1081

```
         Pearson chi2(9) =  799.3153   Pr = 0.000
likelihood-ratio chi2(9) =  750.6341   Pr = 0.000
              Cramer's V =    0.2039
                   gamma =    0.3313   ASE = 0.014
         Kendall's tau-b =    0.2441   ASE = 0.010
```

3.3 Regression Estimates

For getting the regression estimates, the methodology followed was thus: It is being hypothesized that the financial contracts obtained by the firms is determined by firm specific factors - its size, debt, sales and asset position, its future prospects; region specific factors, namely the political situation in the region the firm is situated, the monetary and fiscal policies of the region, and the infrastructure situation as perceived by the firms. So the financial constraints faced by firms was regressed on

(a) infrastructural constraints (b) firm specific factors which determine financial contracts, specifically – value of sales, fixed assets, debt (all taking logs), size characteristics, firms' perceptions about past and future sales, investments and debt values and (c) region specific constraints which could influence financial contracts, viz. the ranking of the nation regarding income, the fiscal and monetary policies of the country, the political instability of the region, the quality of central government, and the corruption levels perceived by firms. (A detailed definition and description of the variables used is given in App. A). Tables 2 onward show both the ordered probit and ordered logit results. We are interested in the relation between the dependent variable being the financial constraints facing the firms (gcf) and the infrastructural constraints facing them (infr_d).

Table 2: Ordered probit estimates on the General Financial Constraints (gcf) facing private/domestic firms (WBES,2002).

Number of obs = 3367; LR chi2(24) = 642.34; Prob > chi2 = 0.0000;
Log likelihood = -4047.7911; Pseudo R2 = 0.0735

gcf	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
country1	**.4318122**	**.08244**	**5.24**	**0.000**	**.2702328**	**.5933916**
country2	**.353737**	**.0630527**	**5.61**	**0.000**	**.230156**	**.4773181**
qgov_d	**.1161673**	**.0407323**	**2.85**	**0.004**	**.0363335**	**.1960011**
gcpi_d	.06682	.0475951	1.40	0.160	-.0264647	.1601047
infl_d	**.1088632**	**.0474302**	**2.30**	**0.022**	**.0159017**	**.2018248**
txreg_d	**.3476044**	**.0525174**	**6.62**	**0.000**	**.2446722**	**.4505365**
gcorr_d	**.2406343**	**.0434523**	**5.540**	**0.000**	**.1554694**	**.325799**
tadm_regd	**.1709161**	**.0447298**	**3.82**	**0.000**	**.0832473**	**.2585849**
size1	**.2976406**	**.0696898**	**4.27**	**0.000**	**.1610512**	**.43423**
size2	**.2424178**	**.0669084**	**3.62**	**0.000**	**.1112797**	**.3735559**
lnvsal	.0030652	.0108683	0.28	0.778	-.0182363	.0243668
lnvfas	.0135233	.0111458	1.21	0.225	-.0083221	.0353688
lnvdebt	**-.024300**	**.0078258**	**-3.11**	**0.002**	**-.0396385**	**-.008962**
fn_re	-.000853	.0005122	-1.67	0.096	-.001857	.0001506
sal_d	-.037877	.0528281	-0.72	0.473	-.1414185	.0656638
salf_d	-.021899	.0546672	-0.40	0.689	-.1290451	.0852465
inv_d	**-.124489**	**.045451**	**-2.74**	**0.006**	**-.2135713**	**-.0354066**
invf_d	.0746657	.0485123	1.54	0.124	-.0204167	.169748
lab_d	.0570087	.044256	1.29	0.198	-.0297315	.1437488

labf_d	.0132834	.0445656	0.30	0.766	-.0740635	.1006303
debt_d	.2412359	.0469151	5.14	0.000	.1492839	.3331879
debf_d	.1342956	.0472459	2.84	0.004	.0416955	.2268958
afs_d	-.064562	.0432783	-1.49	0.136	-.149386	.020262
infr_d	.3772739	.0426074	8.85	0.000	.293765	.4607828
_cut1	.2318569	.1232675	(Ancillary parameters)			
_cut2	.8395603	.1236247				
_cut3	1.66778	.1251726				

gcf	Probability	Observed
no obstacle	Pr(xb+u<_cut1)	0.1491
minor obstac	Pr(_cut1<xb+u<_cut2)	0.1571
moderate obs	Pr(_cut2<xb+u<_cut3)	0.2839
major obstac	Pr(_cut3<xb+u)	0.4099

Table 2.1: Sample Statistics of the Financial Constraints facing firms : Probit Model

Pr(gcf==1)

	Percentiles	Smallest		
1%	.016805	.0085028		
5%	.0264117	.0111069		
10%	.0363703	.0113076	Obs	3382
25%	.0611312	.0114367	Sum of Wgt.	3382
50%	.1117227		**Mean**	**.1486163**
		Largest	Std. Dev.	.1181638
75%	.1996599	.6491151		
90%	.3180288	.6966723	Variance	.0139627
95%	.3877719	.6983643	Skewness	1.44125
99%	.541106	.7171385	Kurtosis	5.047452

Pr(gcf==2)

	Percentiles	Smallest		
1%	.0478262	.0291266		
5%	.0655686	.0354702		
10%	.0812925	.0359377	Obs	3382
25%	.1130827	.0362371	Sum of Wgt.	3382
50%	.1593029		**Mean**	**.1577637**
		Largest	Std. Dev.	.0550815
75%	.2067256	.2387582		
90%	.2321494	.2387586	Variance	.003034
95%	.2374023	.2387588	Skewness	-.1749869
99%	.2387057	.2387591	Kurtosis	1.907029

Pr(gcf==3)

	Percentiles	Smallest
1%	.1613007	.0963894
5%	.2018408	.1045309

10%	.2274336	.105271	Obs	3382
25%	.2650309	.1264649	Sum of Wgt.	3382
50%	.2979814		**Mean**	**.2847372**
		Largest	Std. Dev.	.0388117
75%	.3158797	.3212062		
90%	.320386	.3212062	Variance	.0015064
95%	.3209755	.3212062	Skewness	-1.374217
99%	.3211944	.3212062	Kurtosis	4.538319

Pr(gcf==4)

	Percentiles	Smallest		
1%	.0618846	.0222005		
5%	.1249089	.0252547		
10%	.1678479	.0255418	Obs	3382
25%	.2765617	.0344667	Sum of Wgt.	3382
50%	.4135177		**Mean**	**.4088827**
		Largest	Std. Dev.	.1745411
75%	.5435668	.7994395		
90%	.6400273	.8006518	Variance	.0304646
95%	.6916173	.8025514	Skewness	-.0359967
99%	.7545248	.8291127	Kurtosis	2.169749

Table 3: Ordered Logit Estimates on the General Financial Constraints (gcf) facing Private/domestic firms (WBES, 2002)

Number of obs = 3367; LR chi2(24) = 637.53; Prob > chi2 = 0.0000; Log likelihood = -4050.1943; Pseudo R2 = 0.0730

gcf	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
country1	**.7526405**	**.1378575**	**5.46**	**0.000**	**.4824448**	**1.022836**
country2	**.5926867**	**.1040164**	**5.70**	**0.000**	**.3888182**	**.7965552**
qgov_d	**.2097505**	**.0682455**	**3.07**	**0.002**	**.0759917**	**.3435092**
gcpi_d	.1136429	.0797983	1.42	0.154	-.0427588	.2700447
infl_d	**.1775468**	**.0794326**	**2.24**	**0.025**	**.0218617**	**.3332319**
txreg_d	**.5747604**	**.0882174**	**6.52**	**0.000**	**.4018574**	**.7476633**
gcorr_d	**.3910674**	**.0731885**	**5.34**	**0.000**	**.2476206**	**.5345141**
tadm_regd	**.2767492**	**.0751361**	**3.68**	**0.000**	**.1294851**	**.4240132**
size1	**.4979607**	**.1162416**	**4.28**	**0.000**	**.2701315**	**.72579**
size2	**.4163502**	**.1116201**	**3.73**	**0.000**	**.1975788**	**.6351216**
lnvsal	.0029228	.0182491	0.16	0.873	-.0328449	.0386904
lnvfas	.0232014	.0187301	1.24	0.215	-.0135089	.0599117
lnvdebt	**-.038626**	**.0132012**	**-2.93**	**0.003**	**-.0645**	**-.012752**
fn_re	-.001455	.0008634	-1.69	0.092	-.0031471	.0002372
sal_d	-.038096	.0890218	-0.43	0.669	-.2125754	.1363837
salf_d	-.048070	.0918659	-0.52	0.601	-.2281242	.1319836
inv_d	**-.231266**	**.0765298**	**-3.02**	**0.003**	**-.3812618**	**-.0812706**
invf_d	.110892	.0815559	1.36	0.174	-.0489547	.2707386
lab_d	.0877375	.0740175	1.19	0.236	-.0573341	.2328091

labf_d	.0292579	.0745602	0.39	0.695	-.1168775	.1753932
debt_d	.4010898	.077996	5.14	0.000	.2482204	.5539592
debf_d	.2233626	.0785444	2.84	0.004	.0694183	.3773068
afs_d	-.118261	.072264	-1.64	0.102	-.2598957	.0233739
infr_d	.6261608	.0717253	8.73	0.000	.4855819	.7667398
_cut1	.3430544	.205876	(Ancillary parameters)			
_cut2	1.396923	.2066047				
_cut3	2.765965	.2106662				

gcf	Probability	Observed
no obstacle	Pr(xb+u<_cut1)	0.1491
minor obstac	Pr(_cut1<xb+u<_cut2)	0.1571
moderate obs	Pr(_cut2<xb+u<_cut3)	0.2839
major obstac	Pr(_cut3<xb+u)	0.4099

***Table 3.1*: Sample Statistics of the *Financial* Constraints facing firms : Logit Model**

Pr(gcf==1)

	Percentiles	Smallest		
1%	.0270871	.0172355		
5%	.0367092	.0208478		
10%	.0467015	.0213558	Obs	3382
25%	.0695522	.0214369	Sum of Wgt.	3382
50%	.1132746		**Mean**	**.1489362**
		Largest	Std. Dev.	.1114103
75%	.1912138	.6548852		
90%	.3057353	.6909783	Variance	.0124123
95%	.3768308	.7020864	Skewness	1.590841
99%	.5394117	.7193993	Kurtosis	5.713092

Pr(gcf==2)

	Percentiles	Smallest		
1%	.0468746	.0306657		
5%	.0618392	.0367163		
10%	.0765187	.037557	Obs	3382
25%	.1070239	.0376911	Sum of Wgt.	3382
50%	.1549103		**Mean**	.1584705
		Largest	Std. Dev.	.0621099
75%	.2124117	.2575355		
90%	.2475532	.2575355	Variance	.0038576
95%	.2554116	.2575355	Skewness	.0388674
99%	.2574556	.2575357	Kurtosis	1.81254

Pr(gcf==3)

	Percentiles	Smallest
1%	.1472111	.0862648
5%	.1865354	.0925969

10%	.2155495	.0967304	Obs	3382
25%	.2589253	.1105528	Sum of Wgt.	3382
50%	.2990818		Mean	.2843154
		Largest	Std. Dev.	.0459639
75%	.322472	.3294934		
90%	.3282984	.3294937	Variance	.0021127
95%	.3292058	.3294939	Skewness	-1.200647
99%	.329472	.3294939	Kurtosis	3.850178

Pr(gcf==4)

	Percentiles	Smallest		
1%	.0703788	.0334269		
5%	.127874	.036258		
10%	.1675938	.0381399	Obs	3382
25%	.2727394	.0446385	Sum of Wgt.	3382
50%	.4097037		Mean	.408278
		Largest	Std. Dev.	.1761218
75%	.5425661	.8018758		
90%	.6441087	.8024908	Variance	.0310189
95%	.6993946	.8063595	Skewness	.0231892
99%	.7610283	.8348624	Kurtosis	2.120622

Tables 2 and 3 indicate that both logit and probit models predict that the infrastructural dummy (infr_d) is positively significant in determining the credit difficulties faced by firms. The estimate on infr_d being positive indicates that "other things being equal", those firms who faced major infrastructural difficulties had a higher probability of having moderate/major financial constraints and a lower probability of having no/minor financial constraints, compared to firms having no or minor infrastructural difficulties.

The two models also suggest that among the "region specific" factors determining credit constraints: Both low income and middle income countries had a greater probability of having major financial constraints, as compared to high income countries. (The coefficient was higher in the case of low income countries in comparison to middle income countries, indicating that Ceteris Paribus, firms in the low income countries had the highest probability of having major financial constraints). Other region specific factors which turn out to be significant are the dummy for quality of central government (qgov_d), the inflation dummy(infl_d) the dummy for taxes and regulations in a country (txreg_d), the dummy for corruption (gcorr_d), and the dummy for tax administration and regulations (tadm_regd). Other things being equal, those firms which faced poor quality governance, high levels of inflation, high corruption, and constricting tax laws and tax administration had a higher probability of having moderate/major financial constraints, and a lower probability of having no/minor financial constraints. The dummy for political instability (gcpi_d) turned out to be insignificant in both the models.

Regarding the "firm specific" factors, the size of the firm (size1 and size2) and all the debt variables, log of the value of present debt and the firms' perceptions of the past and future debt levels turn out to be significant (lnvdebt, debt_d and debf_d). Small and medium firms have a greater probability of having moderate/major financial constraints as compared to large firms. The firms' existing debt position (lnvdebt) is negatively significant in both models. Those firms who had higher debt values had a lower probability of having major/moderate financial constraints as compared to firms who had lower debt. Also those firms who had increased debt in the past 3 years and expected an increase in their debt levels over the next 3 years were more likely to have moderate/major financial constraints. This suggests that firms whose existing debt values were low, and who were expecting to borrow in the future are the ones who are most likely to say that financial difficulties are greater. The dummy for increased investment in the past 3 years (inv_d) is negatively significant in both models, meaning that those firms whose investment levels increased in the past 3 years had a lower probability of having major/moderate financial constraints, as compared to firms whose investment levels did not increase.

A display at the bottom of tables 2 and 3 show how the probabilities for the categories were computed from the fitted equation. Notwithstanding the differences in the coefficients between the logit and the probit models, the predicted probabilities are similar, so in this case it does not matter which model is being used.

Table 4: Overall Probability of having financial constraints: Probit Model

Probability of having	CALCULATED AS Mean of individual Probabilities (p)	CALCULATED FROM Mean of Determining Variables (q)
No financial constraints	.1486163	.1209111
Minor fin. constraints	.1577637	.1658946
Moderate fin. constraints	.2847372	.3178739
Major fin. constraints	.4088827	.3953204

Table 5: Overall Probability of having financial constraints: Logit Model

Probability of having	CALCULATED AS Mean of individual Probabilities (p)	CALCULATED FROM Mean of Determining Variables (q)
No financial constraints	.1489362	.1212659
Minor fin. constraints	.1584705	.1623435
Moderate fin. constraints	.2843154	.3252247
Major fin. constraints	.408278	.3911659

Tables 4 and 5 show the sample statistics of the financial constraints facing the firms, generated form the individual probabilities of the firms, using both probit and logit estimates. The mean probabilities (p) in the case of the logit and probit models are shown in the column 1 of tables 4 and 5 (Mean of individual probabilities, p). They are similar and after rounding off, and are equal to 15%, 16%, 28% and 41% respectively for the 4 levels of financial constraints. These estimates can be compared to the actual sample proportions shown by the data. The sample proportions of the firms having no/minor/moderate/major financial constraints are 17.06%, 16.87%, 27.83%. and 38.24%. The mean probabilities of both the logit and the probit models are thus close to the sample proportions.

There is an alternative way of calculating the mean probabilities and this leads to a different outcome from those set above. The intuition behind this method is constructing a "straw firm" which has the mean value of all the determining variables, and embodies the average attributes of the sample. This method by-passes the individual probabilities, and calculates the probabilities directly as the probability faced by this "straw firm". These are given for both probit and logit in column 2 of tables 4 and 5 (Mean of determining variables, q).

Two features of this table are significant. First, for any two ways of computing marginal effects there was hardly any difference between probit and logit probabilities. Second, for any one model there was considerable difference between the probabilities calculated in the two different ways. The probability of having no financial constraints and major financial constraints is higher when the probabilities are computed as the mean of the individual probabilities (p) than when they were computed from the average characteristics of the firms (q). This is not surprising. Both these rankings are the result of possessing "extreme" values of the determining variables. This influence of the extreme values is dampened when the individual values are set equal to the sample averages. On the other hand, the extreme values are allowed full play when the individual values are used in probability calculations.

3.4 The Infrastructure - Finance link

The effect of the dummy variable (infr_d) should be analyzed by comparing the probabilities that result when the dummy variable takes one value with the probabilities that are the consequence of it taking the other value, the values of the other variables remaining unchanged between the two comparisons.

Table 6: The effect of Infrastructure on the probability rankings of financial constraints: Probit Model

	CALCULATED as: Mean of individual Marginal Effects.		CALCULATED as: Mean of Determining Variables.	
Probabilities (gcf)	Infr_d = 1	Infr_d = 0	Infr_d = 1	Infr_d = 0
No financial constraint	.0994008	.172585	.0796417	.1514553
Minor fin. constraint	.1317345	.1749444	.1322767	.1848717
Moderate fin. constraint	.2768532	.2954325	.2994248	.3211955
Major fin. constraint	.4920115	.3570382	.4886568	.3424775

Table 7: The effect of Infrastructure on the probability rankings of the financial constraints : Logit Model

Probabilities (gcf)	CALCULATED as: Mean of individual Marginal Effects. Infr_d = 1	Infr_d = 0	CALCULATED as: Mean of Determining Variables. Infr_d = 1	Infr_d = 0
No financial constraint	.1033321	.1707017	.0851831	.14833
Minor fin. constraint	.1296224	.1767693	.1256266	.1848381
Moderate fin. constraint	.2749876	.2969861	.3014354	.3294875
Major fin. constraint	.4920579	.3555429	.487755	.3373444

This methodology is now used to analyze the effect of the infrastructural dummy on the ranking of the firms as regards financial constraints by comparing the different probabilities in which infr_d = 1(firms have major/moderate infrastructure constraints) with the situation in which infr_d = 0(firms have minor/no infrastructure constraints). This methodology can be again implemented in two ways:

(i) In the first method, we start by making all firms in the sample have high infrastructural constraints. We then calculate the individual probabilities under this hypothetical situation. These probabilities are given in column 1 in table 6 and 7 under Probit and Logit models respectively. Then we suppose all firms in the sample have no infrastructural constraints, the individual probabilities under this second hypothetical situation is given in cols 2 of table 6 and 7. The difference between the cols 1 and 2 therefore the difference in the individual probabilities with the infrastructural constraint "switched on" and "switched off" respectively, with the value of no other variable altered.

(ii) In the second method, we compare the probabilities that result when the dummy infr_d takes its two different values across all the firms in the sample, with the values of other variables, in each case, held at their sample means. This method thus compares the "straw firm" who apart from infrastructural constraints embodies the average characteristics of all the firms in the sample and who has infrastructural constraints in one scenario and no infrastructural constraints in another scenario. The estimates of the four probabilities, of having no/minor/moderate and major financial constraint can be compared under the two hypothetical situations – first, when this firm has infrastructural constraint and second, when it doesn't (columns 3 and 4 of table 6 and 7).

As we saw in the earlier tables, two features of the tables 6 and 7 are significant. First, for any two ways of computing the marginal effects there was not much difference between the logit and the probit models. Second, for any one model, there was considerable difference in the probabilities calculated in the two different ways. The probability of the firms having both no and major financial constraint was higher when the probabilities were computed as a mean of the individual probabilities (method (i)) than when they were computed from the average characteristics of the sample (method (ii)). This is because in the latter method, the influence of extreme values is dampened when individual values of the determining variables are set equal to sample averages. Barooh, V.K (2001) suggests that the critical question is how the values of the other variables are to be held constant, when the dummy variable of interest takes two different values. The second method assigns to each firm the values of the sample means. The common value assigned could be the median, in which case there will be different outcomes. The first method on the other hand calculates the mean from the individual probabilities and therefore realizes a unique outcome under the two scenarios, in terms of the mean probabilities.

Table 8: Finance as a constraint for Firms by difficulties faced as regards Infrastructure.

PERCENTAGE OF FIRMS THAT HAVE:

	No financial Constraints	Minor fin. constraints	Moderate fin. constraints	Major fin. constraints
All firms	17.06	16.87	27.83	38.24
All firms having Infrastructural constraints	7.5	12.7	26.5	53.3
All firms having no infrastructural constraints	19.2	17.6	29.4	33.8

The table above shows the summary statistics regarding the Infrastructure-finance linkage obtained from the data. As we see, row 1 indicates the ranking of all firms re. Finance constraint ranking. Row two shows the probabilities among those firms who have moderate/major ranking for infrastructure constraints (infr_d = 1) Row 3 shows the probabilities for firms where the infrastructure dummy takes value infr_d = 0 (no/minor infrastructural constraints). As we see, firms indicating that they major financial constraints increases considerably when all firms are facing infrastructural constraints as compared to when they are not (53.3% as compared to 33.8%). On the other hand, the percentage of firms indicating that they have no financial constraints decreases considerably (7.5% as compared to 19.2%).

All the tables above trace the effect that infrastructure has on the financial constraints facing the firm by analyzing coefficient on the dummy variable infr_d. The probability of having a high/low ranking on the financial constraint was different for each firm having infr_d = 0 than for a firm having infr_d = 1. But this could mean that the coefficients of every determining variable could be different in each of the two subgroups considered. In other words, the equation should have been re-estimated allowing for the coefficients of all the other determining variables to be different in the groups when infr_d = 0 and when infr_d = 1. In other ways, we have to allow for the fact that all other determining regressors (the region specific and firm specific variables) could be different depending on whether the firm faces infrastructure constraints (infr_d = 1) or whether the firm faces no infrastructure constraints (infr_d = 0).

One way of doing this is to allow for "interaction variables" in estimating the equation. We multiply the regressors by the infrastructure dummy. So, when infr_r = 1, the coefficients attached to the interaction variables represent the additional contribution to these coefficients resulting from the firm having infrastructural constraints. This is the single equation "integrated" approach.

The second approach is to estimate two separate equations on the two subgroups, one which has infrastructural constraints (infr_d = 1) and the other which has no infrastructural constraints (infr_d = 0). This second approach is summarized in Table 8, which shows respectively the results of the logit estimations separately when firms face infrastructure constraints (infr_d = 1) and when they face no infrastructural constraints (infr_d = 0).

These regressions are shown below in tables 9 and 10, where the insignificant variables were dropped. This is because their coefficients were individually and jointly not significant from zero. This is an important methodological point: When equations are used for prediction should they contain *all the* variables, even though some of the coefficients may not be significantly *different from zero* or should they contain only those variables with significantly non zero coefficients? One argument is that if one believed a priori that a variable had a legitimate place in the equation specification then one should persist with this belief and include it. The other argument is that the purpose and of estimation and prediction is to confront equation specification with data, to base predictions on the coefficient estimates obtained from full specification may be misleading since it would allow variables whose legitimacy in the specification had been "rejected" by the data, to influence the predictions (Borooah, 2003). So, while Table 8 summarized the estimations based on the whole set of variables, tables 9 and 10 show the same based on a restricted specification.

It is interesting to see that in this restricted specification, some of the region specific variables, namely the quality of central government (qgov_d), the level of inflation in a country (infl_d) and the tax and regulatory policies (txreg_d) turn out to be insignificant when all firms are made to have infrastructural constraints, but they remain significant when firms are made to have no infrastructural constraints. This means that the effectiveness of these variables on financial constraints facing the firm is nullified to a great extent when firms face infrastructural difficulties. Since provision of infrastructure is one of the basic factors determining the business environment facing the firms, we could say that the effectiveness of these monetary and fiscal factors is realized only when the firms have fewer constraints with regard to infrastructure.

Table 9: Ordered Logit on the Ranking of firms re. infrastructural constraints : Sub-sample of firms having Infrastructural constraints (infr_d = 1).

```
Ordered logit estimates                          Number of obs   =       1267
                                                 LR chi2(14)     =     126.28
                                                 Prob > chi2     =     0.0000
Log likelihood = -1380.5618                      Pseudo R2       =     0.0437
```

gcf	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
country1	**.8091416**	**.2357151**	**3.43**	**0.001**	**.3471484**	**1.271135**
country2	**.5023055**	**.1956456**	**2.57**	**0.010**	**.1188472**	**.8857637**
qgov_d	.1802941	.1163144	1.55	0.121	-.047678	.4082663
infl_d	.1799364	.1365316	1.32	0.188	-.0876606	.4475334
txreg_d	.2681226	.1739174	1.54	0.123	-.0727493	.6089946
gcorr_d	**.5235881**	**.1210447**	**4.33**	**0.000**	**.2863448**	**.7608314**
tadm_regd	**.3078607**	**.1291084**	**2.38**	**0.017**	**.0548129**	**.5609085**
size1	**.6100626**	**.177939**	**3.43**	**0.001**	**.2613085**	**.9588167**
size2	**.4637863**	**.1701533**	**2.73**	**0.006**	**.1302921**	**.7972806**
lnvdebt	**-.017755**	**.0075727**	**-2.34**	**0.019**	**-.0325974**	**-.0029129**
fn_re	-.001653	.0014582	-1.13	0.257	-.0045108	.0012051
inv_d	-.141776	.1176203	-1.21	0.228	-.372307	.0887561
debt_d	**.3649487**	**.1289211**	**2.83**	**0.005**	**.1122679**	**.6176294**
debf_d	**.2920326**	**.1265891**	**2.31**	**0.021**	**.0439226**	**.5401426**
_cut1	-.658983	.3449017			(Ancillary parameters)	
_cut2	.5433287	.3399581				
_cut3	1.89135	.344221				

gcf	Probability	Observed
no obstacle	Pr(xb+u<_cut1)	0.0742
minor obstac	Pr(_cut1<xb+u<_cut2)	0.1255
moderate obs	Pr(_cut2<xb+u<_cut3)	0.2644
major obstac	Pr(_cut3<xb+u)	0.5359

Table 10: Ordered Logit on the Ranking of firms re. infrastructural constraints : Sub-sample of firms having No Infrastructural constraints (infr_d = 0).

```
Ordered logit estimates                           Number of obs   =      2143
                                                  LR chi2(14)     =    357.91
                                                  Prob > chi2     =    0.0000
Log likelihood = -2712.3243                       Pseudo R2       =    0.0619
------------------------------------------------------------------------------
     gcf |      Coef.   Std. Err.       z     P>|z|       [95% Conf. Interval]
---------+--------------------------------------------------------------------
country1 |   .6794663   .1735802     3.91   0.000       .3392555    1.019677
country2 |   .6161416   .1208231     5.10   0.000       .3793327    .8529505
  qgov_d |   .2595773   .0832398     3.12   0.002       .0964303    .4227244
  infl_d |   .2208901   .0912711     2.42   0.016       .0420022    .3997781
 txreg_d |   .6973715    .100352     6.95   0.000       .5006853    .8940577
 gcorr_d |   .3493381      .0883     3.96   0.000       .1762732     .522403
tadm_regd|   .2763815   .0914586     3.02   0.003       .0971259     .455637
   size1 |    .430622   .1461425     2.95   0.003       .1441881     .717056
   size2 |   .3915279   .1457874     2.69   0.007       .1057898     .677266
 lnvdebt |   -.016495   .0057232    -2.88   0.004      -.0277122   -.0052778
   fn_re |   -.001333   .0010599    -1.26   0.209      -.0034099    .0007447
   inv_d |   -.224072   .0843697    -2.66   0.008      -.3894337   -.0587107
  debt_d |    .437958   .0948721     4.62   0.000       .2520121    .6239038
  debf_d |   .2406936   .0945318     2.55   0.011       .0554148    .4259725
---------+--------------------------------------------------------------------
   _cut1 |   .3813447   .2302995          (Ancillary parameters)
   _cut2 |   1.394558   .2316537
   _cut3 |   2.770673   .2371747
------------------------------------------------------------------------------
         gcf |      Probability                 Observed
-------------+-------------------------------------------
 no obstacle |      Pr(        xb+u<_cut1)       0.1923
minor obstac |      Pr(_cut1<xb+u<_cut2)         0.1759
moderate obs |      Pr(_cut2<xb+u<_cut3)         0.2935
major obstac |      Pr(_cut3<xb+u)               0.3383
```

3.5 Estimation over sub-samples - Characteristics versus coefficients

Table 8 tells us that 8% and 13% of the firms having infrastructural constraints had no/minor financial constraints and 27% and 53% of them had moderate/major financial constraints. While 20% and 18% of the firms having no infrastructural constraints had no/minor financial constraints and 29% and 34% of them had moderate/major financial constraints. The fact that larger proportion of firms having no infrastructural constraints had no/minor financial constraints could be due to two reasons. First, all those characteristics which increased the probability of a firm having high financial constraints could be concentrated among those firms which faced high infrastructural constraints, or those characteristics which reduced the probability of a firm having high financial constraints could be concentrated among those firms which faced low infrastructural constraints. Or maybe a particular attribute which increased the probability of a firm having high financial constraint (being of a smaller size, present in a low-income country, facing high inflation levels etc...) were penalized more harshly if the firm faced infrastructural constraints. So, we have to find out how much of the financial constraint gap between firms having infrastructural constraints and firms having no infrastructural constraints was due to differences in characteristics and how much was it due to the differences in coefficients. We ask the following questions:

(i) What would have been the predicted probabilities of the two different groups of firms (one having infrastructural constraints, and the other not having them) if the characteristics possessed by each group were evaluated using their own coefficients? That is, we evaluate the predicted probabilities of firms having infrastructural constraints and firms having no infrastructural constraints each at their own coefficients.

(ii) Then we evaluate the probabilities of firms with low infrastructural constraints at the coefficients of firms with high infrastructure constraints. These are "synthetic" probabilities.

(iii) We then compare the three probabilities.

The same is done for sub-groups of firms, as per country and as per size. It gives an indication of the difference in rankings being due to difference in the characteristics of firms, or due to the difference in coefficients.

We see that when firms with low infrastructure constraints were evaluated at their own coefficients, we see that their probability of having no/minor/moderate and major financial constraints were 19%, 18%, 29% and 34% respectively. When the characteristics of these firms were evaluated at the coefficients of firms having high infrastructure constraints, the probability of having no/minor financial constraints fell to 10% and 15% respectively. The probability of having moderate financial constraints remained more or less same at 28%, but the probability of having major financial constraints rose sharply to 47%. The story was repeated for the sub-groups considered with respect to the size of firms, and the country in which the firms operate.

Table 11: Predicted Probabilities of Firms with Infrastructural Constraints and Firms with no Infrastructural constraints having different rankings regarding Financial Constraints.

PREDICTED PROBABILITY OF HAVING:

	No fin. Constraint	Minor fin. constraint	Moderate fin. constraint	Major fin. constraint
All Firms				
Firms with low infrastructure constraints at their own coefficients	19.1	17.7	29.5	33.7
Firms with low infr. constraints at the coefficients of firms with high infr. Constraints	9.6	15	27.9	47.4
Firms with high infrastructure constraints at their own coefficients	7.4	12.7	26.5	53.4

Small Sized firms	**No financial Constraint**	**Minor fin. constraint**	**Moderate fin. Constraint**	**Major fin. constraint**
Firms with low infrastructure constraints at their own coefficients	17.9	17.4	29.9	34.9
Firms with low infr. constraints at the coefficients of firms with high infr. Constraints	8.4	13.9	27.5	50.2
Firms with high infrastructure constraints at their own coefficients	6.3	11.3	25.4	57.1
Medium sized firms	**No financial Constraint**	**Minor fin. constraint**	**Moderate fin. constraint**	**Major fin. constraint**
Firms with low infrastructure constraints at their own coefficients	18.8	17.4	29.4	34.5
Firms with low infr. constraints at the coefficients of firms with high infr. Constraints	9.8	15.2	28	47
Firms with high infrastructure constraints at their own coefficients	7.2	12.5	26.5	53.8
Large Sized firms	**No financial Constraint**	**Minor fin. constraint**	**Moderate fin. constraint**	**Major fin. constraint**
Firms with low infrastructure constraints at their own coefficients	27.3	20.6	28	24.1
Firms with low infr. constraints at the coefficients of firms with high infr. Constraints	15.6	20.3	29.8	34.3

Firms with high infrastructure constraints at their own coefficients	12.2	18.1	30.2	39.5
Firms in low income countries	**No financial Constraint**	**Minor fin. constraint**	**Moderate fin. constraint**	**Major fin. constraint**
Firms with low infrastructure constraints at their own coefficients	16.2	16.6	29.9	37.3
Firms with low infr. constraints at the coefficients of firms with high infr. Constraints	6.5	11.5	25.4	56.6
Firms with high infrastructure constraints at their own coefficients	5.1	9.7	23.7	61.4
Firms in medium income countries	**No financial Constraint**	**Minor fin. constraint**	**Moderate fin. constraint**	**Major fin. constraint**
Firms with low infrastructure constraints at their own coefficients	16.2	16.8	30.3	36.8
Firms with low infr. constraints at the coefficients of firms with high infr.	8.2	13.8	27.7	50.2
Firms with high infrastructure constraints at their own coefficients	7.2	12.5	26.7	53.5
Firms in high income countries	**No financial Constraint**	**Minor fin. constraint**	**Moderate fin. constraint**	**Major fin. constraint**
Firms with low infrastructure constraints at their own coefficients	35.1	22.7	24.5	16.8
Firms with low infr. constraints at the coefficients of firms with high infr. Constraints	18.5	23	30.1	28.4

Firms with high infrastructure constraints at their own coefficients	14	19.6	30.2	36.3

With no exceptions we find that with respect to all sub-groups, the probability of having no financial constraints always fell and the probability of having major financial constraints rose when the firms having *low* infrastructure constraints were evaluated at the coefficients of the firms with having *high* infrastructure constraints, though the magnitude of these changes always varied as per the sub-group being considered. In the case of firms as per the countries in which they were situated, this pattern was sharper for firms in the high-income countries. This was in contrast to the firms in low-income countries, which were more varied in terms of spread of countries. With respect to firm size, the sharpest fall (in the probability of having no financial constraints) and the sharpest rise (in the probability of having major financial constraints) were in the case of the small-sized and medium sized firms. This definitely reinforces the analysis that it is the smaller and medium sized firms who benefit most from good infrastructure.

3.6 Conclusion

This empirical study re-enforces the link between infrastructure and private sector productivity. One of the crucial aspects of private sector productivity is the ease with which they can borrow and fulfill their contracts in the capital market. The quality of the infrastructure facing the firm crucially determines the difficulties they face as regards finance. By showing that firms facing high infrastructural constraints are the ones most likely to face high financial constraints as well, this study points out to the fact that the provision of good quality infrastructure considerably eases the problem of getting finance for firms. By analyzing firm level, qualitative data this study points out to a major link through which infrastructure can affect private sector productivity.

While this should not be seen as one of the solutions by which the financial constraints of the firms can be ameliorated, it does go a long way in pointing out the "spill-over" benefits of building good infrastructure. This is especially crucial in the case of small-sized firms who are resource constrained and who will derive the maximum benefits from good quality public infrastructure. In the case of high-income countries, this infrastructure-finance link is more potent as compared to the low-income countries.

3.A Appendix : Definitions of variables

Dependant variable : gcf – General constraint – financing (no obstacle; minor obstacle; moderate obstacle; major obstacle)

Independent variables:

- Region specific variables influencing financial constraints faced by a firm:

1. country1 - low income country dummy
2. country2 - middle income country dummy
3. qgov_d - Dummy for quality of central govt. in a country (1 = quality – slightly bad to very bad; 0 = quality very good to slightly good)
4. gcpi_d - Dummy for political instability in a country (1 = political instability is a major/moderate constraint; 0 = political instability is no/minor constraint)
5. infl_d - Dummy for inflation in a country (1 = inflation is a major/moderate constraint; 0 = inflation is no/minor constraint)
6. txreg_d - Dummy for taxes and regulations in a country (1 = taxes and regulations are major/moderate constraint; 0 = taxes and regulations are a no/minor constraint)
7. gcorr_d - Dummy for corruption levels in a country (1 = corruption is a major/moderate constraint; 0 = corruption is no/minor constraint)
8. tadm_regd - Dummy for tax-administration regulations (1 = tax-adm. regulations are a major/moderate constraint; 0 = tax-adm. regulations are a no/minor constraint)

9. infr_d - Dummy for infrastructural constraints (1 = infrastructure is a major/moderate constraint; 0 = infrastructure is no/minor constraint)

- **Firm specific variables influencing financial constraints faced by a firm:**

10. size1 - Dummy for small firms

11. size2 - Dummy for medium firms

12. lnvsal – log of the value of sales(vsal) ($)

13. lnvfas – log of the value of fixed assets (vfas) ($)

14. lnvdebt – log of the Value of debt (vdebt)

15. fn_re - source of investment finance – retained earnings (1 = yes; 0 = no)

16. sal_d - dummy for increase in sales over the past 3 years (1 = yes; 0 = no)

17. salf_d - dummy for expected increase in sales the next 3 years (1 = yes; 0 = no)

18. inv_d - dummy for increase in investments over the past 3 years (1 = yes; 0 = no)

19. invf_d - dummy for expected increase in investments over the next 3 yrs (1 = yes; 0 = no)

20. debt_d - dummy for increase in debt over the past 3 years (1 = yes; 0 = no)

21. debf_d - dummy for expected increase in debt the over the next 3 years (1 = yes; 0 = no)

22. lab_d - dummy for increase in employment over the past 3 years (1 = yes; 0 = no)

23. labf_d - dummy for expected increase in employment over the next 3 years (1 = yes; 0 = no)

24. afs_d - dummy for audited financial statements (1 = yes; 0 = no)

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