Financial Frictions, Intermediate Goods and Total Factor Productivity

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Abstract

Poor countries are characterized by an abundance of low-skilled entrepreneurship. I develop a Lucas span-of-control model in which low-skilled entrepreneurship arises endogenously due to financial frictions. Financial frictions arise due to unobservable entrepreneurial skill and imperfect contract enforceability. The optimal contract between financial intermediaries and entrepreneurs features credit rationing and a low ratio of good to bad projects. In the aggregate, all these firms are interconnected not only through prices but also by the use of intermediate goods. I show that these frictions aggregate to produce large differences in TFP and income per capita. The fact that the model replicates well the relative prices of intermediate goods across countries provides support for the importance of this channel in explaining income per capita differences.

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1 Introduction

Cross-country data features up to 50-fold differences in income per capita (Jones, 2010). Hsieh and Klenow (2010) summarize the current state of the debate of the proximate causes of income per capita differences as follows: differences in human capital account for about 10-30 percent of income differences, differences in physical capital account for about 20 percent, and residual total factor productivity (TFP) remains the biggest source of income per capita differences accounting for about 50-70 percent. This paper takes the view that financial frictions show up as TFP differences, and asks how much can financial frictions account for cross-country TFP and income per capita differences.

I develop a theory of TFP around three observations of developing countries. Poor countries are characterized by 1) a large fraction of the population employed in industries with low return to labor, 2) use of inefficient technologies, and 3) high relative prices of intermediate goods.[1] The reason for focusing on these three observations is that, together, they form a structured story of development. Broadly speaking, barriers to factor mobility lie at the source of the distortion, use of inefficient technologies constitutes the distortion, and intermediate goods provide an amplification mechanism for small distortions to produce large TFP differences.

In the model, agents are born with an endowment of labor and a technology and they make a decision to work for a wage or operate their technology. Some agents have high entrepreneurial skill and some have low skill. I use the concept of inefficient technology and low skill interchangedly, with the understanding that skill level can stand for many different things, such as quality of ideas to start a business, managerial talent (as in the original Lucas span-of-control model), or simply as productivity. Agents need financing to operate their technology, but financing is hindered by the fact that entrepreneurial skill is unobservable and there is limited punishment for agents who misreport their skill type (imperfect contract enforceability). The imperfect contract enforceability is a stand-in for the strength of institutions and reflects the fact that income-per-capita is highly correlated with all sorts of institutional variables such as strength of property rights and the ability of banks to collect unpaid loans (LaPorta et al., 1998).

Poorer countries have lower contract enforceability, which leads lenders to lower the ratio of good to bad projects in order to prevent low-skilled agents from misreporting their type. Industries with higher financing needs have more binding constraints, which means lower ratio of good to bad projects, higher marginal product of labor, and lower employment in the industry. Each good produced can be used as an intermediate good for other industries to use as an input in their own production, or can be used as a final good. Intermediate goods cause distortions to be multiplied across the economy, as it not only affects the firm facing the distortion but also all other firms across the supply chain.

An advantage of the theory is its analytical tractability. There is a closed-form solution

[1] Observations 1 and 3 are well-documented facts in papers such as Erosa and Cabrillana (2008) and Restuccia et al. (2008). Parente and Prescott (1999, 2002) explore observation 2 and provide a wealth of supportive evidence.

for TFP where the role of distortions and the multiplier are transparent. Finally, the model's assumptions are made so that it can be easily mapped to data to quantify the impact of financial distortions on TFP.

2 (Short) Literature review

The two closest papers to mine are Erosa and Cabrillana (2008) and Jones (forthcoming). Erosa and Cabrillana (2008) also develops a theory of TFP based on financial frictions that arise due to unobservability of entrepreneurial ability and imperfect contract enforceability. The main difference between our papers is that theirs is a theoretical paper while mine is (will be) quantitative as well, and they model the intermediate goods sector as a separate sector that doesn't use intermediate goods in its production. This is an important difference, both theoretically, quantitatively, and for mapping the model to the data. This assumption and several others I make, such as a decreasing returns to scale technology, make the mapping of the model to NIPA accounts more transparent.

Jones (forthcoming) focuses on the multiplier properties of intermediate goods. In this paper, Jones points out that growth theories with large multipliers should have a reason within the model of why growth miracles are rare. The main difference between our papers is that I have an explicit distortion and the reason why reforms are hard is different. In Jones' story, it is a combination of idyosincratic shocks and high complementarity that makes growth miracles rare. In my model, it is the fact that entrepreneurs as a class make positive economic rents with poor institutions, and thus incumbents have vested interest in keeping institutions underdeveloped.

It is also worth mentioning how this paper differs from others in the growing literature of effects of financial frictions on economic growth (Greenwood et al., 2010a,b; Buera et al., forthcoming; Buera and Shin, 2008; Amaral and Quintin, 2010). Besides having different models with different financial frictions, financial frictions in this paper can explain larger TFP differences. This is in spite that all firms in my model operate at optimal capacity given market conditions. Most other papers have not only lower average productivity but also inefficient firm sizes.

My paper is also related to a growing literature that focuses on how misallocation of resources shows up as TFP differences. The most prominent papers in this regard are Restuccia and Rogerson (2008) and Hsieh and Klenow (2009).

3 The Model

The setting is a static model that can be thought of as a world resting on a steady state. At the individual level, the setup is that of a Lucas span-of-control economy. In the aggregate, intermediate goods drive a multiplier and produce the high relative price of intermediate goods in developing countries.

3.1 Individual Problem

Consider a one-period economy populated by a continuum of risk neutral agents of mass 1 who consume by the end of the period. Agents are born with one unit of a consumption good, one unit of labor and a industry-specific technology

$$Q_{ij} = A_i (N_{ij}^{\gamma})^{1-\sigma} X_{ij}^{\sigma} \tag{1}$$

with $\gamma, \sigma \in (0,1)$, entrepreneurial skill A_i, labor N_i, and intermediate good X_i. Subscript i refers to skill level $i \in \{low, high\}$ and subscript j refers to an industry. A fraction ν of agents are endowed with low entrepreneurial skill A_ℓ and a fraction $1-\nu$ are endowed with high entrepreneurial skill A_h. Agents decide whether to operate their technology or work for a wage. The need for finance arises because operating a technology requires the payment of an industry-specific fixed cost $f_j > \eta$, where $\eta = 1$ is the endowment of consumption good. The cost function for the entrepreneur that wants to operate his technology is given by

$$c(Q_{ij}) = \min_{N_{ij}, X_{ij}} wN_{ij} + qX_{ij} + f_j \tag{2}$$

$$s.t. \quad : \quad A_i (N_{ij}^{\gamma})^{1-\sigma} X_{ij}^{\sigma} = Q_{ij} \tag{3}$$

where w is the cost of labor. Let $a = \gamma(1-\sigma)$ be the share of labor in production and $b = \sigma$ the share of intermediate goods in production. The solution to this problem is

$$c(Q_{ij}) = \psi A_i^{-\frac{1}{a+b}} Q_{ij}^{\frac{1}{a+b}} + f_j \tag{4}$$

where $\psi \equiv (a+b) \left(\frac{w}{a}\right)^{\frac{a}{a+b}} \left(\frac{q}{b}\right)^{\frac{b}{a+b}}$. Profit maximizing output for agent i is

$$\bar{Q}_{ij} = A_i^{\frac{1}{1-a-b}} p^{\frac{a+b}{1-a-b}} \left(\frac{a}{w}\right)^{\frac{a}{1-a-b}} \left(\frac{b}{q}\right)^{\frac{b}{1-a-b}} \tag{5}$$

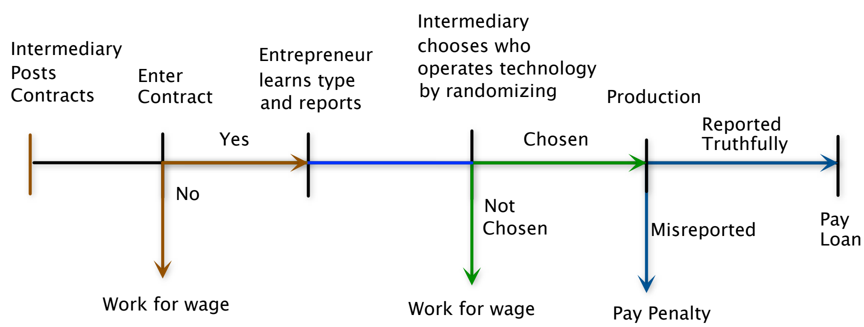
where p is the price of output. To make the notation tractable we drop the industry arguments from here on, with the understanding that quantities differ across industries.

There are two frictions that make financing difficult. First, entrepreneurial skill is unobservable. Second, imperfect contract enforceability implies that lenders can only collect payments up to a fraction ϕ of output. Output is observable and therefore all information is revealed by the end of the period.

In this framework financial intermediaries arise as an incentive compatible mechanism to allocate resources among entrepreneurs. Financial intermediaries announce production plans and repayment schedules for each type of entrepreneur. A production plan specifies for each type of entrepreneur i the fraction of entrepreneurs e_i that operate their technology, the output Q_i produced, and the repayment schedule.[2] Entrepreneurs that reported their type truthfully

[2]Rationing amount of projects by randomizing convexifies the occupational choice decision and is less distortive than restricting firm sizes and funding all projects, as long as their is an optimal firm size.

pay amount L_i and agents that misreported their type pay an amount L_i^F (superscript F stands for false). In order to avoid problems of inexistence of equilibria with adverse selection I assume that financial intermediaries announce contracts before agents learn their type. The timing of events is as follows:



1. Financial intermediaries post contracts. Each contract is an 8-tuple $\{(e_l, Q_l, L_l, L_l^F), (e_h, Q_h, L_h, L_h^F)\}$. For each ability type, i, the contract specifies the fraction of entrepreneurs that operate their production technology, e_i, while the rest (fraction $1 - e_i$) work for a wage. For entrepreneurs who are chosen to operate their technology, the contract specifies how much output they produce Q_i and repayment schedule (L_i, L_i^F). The financial intermediary finances production with entrepreneur's consumption good endowment η.

2. Entrepreneurs decide whether to contract with the financial intermediary. Given that the intermediary's goal is to maximize agents' expected consumption, all agents are weakly better off contracting with intermediary.

3. Entrepreneurs learn their ability type and report it to the financial intermediary.

4. The financial intermediary chooses the entrepreneurs that operate their technology for each type (through a randomization device). This randomization device can be thought of as a form of credit rationing.

5. Entrepreneurs that are chosen incur fixed cost f, hire labor N_i and use intermediate inputs X_i, with resources provided by the financial intermediary. The entrepreneurs that are not chosen to operate their production technology supply their labor, earn the market wage rate and consume.

6. If the entrepreneur reported his skill truthfully he consumes $pQ_i - L_i$ and if he reported falsely he consumes $pQ_i - L_i^F$.

Financial Intermediaries maximize entrepreneur's expected consumption subject to resource feasibility, enforcement, incentive compatibility, and participation constraints, as described below.

The Intermediary's Problem

The revelation principle allows us to focus, without loss of generality, on allocations where agents report their types truthfully.

The objective of the financial intermediary is to choose quantities $(c_l, e_l, Q_l, L_l, L_l^F)$, $(c_h, e_h, Q_h, L_h, L_H^F)$ such that

1. Entrepreneur's expected consumption is maximized (before they know their ability),

$$\max c^e = \nu c_l + (1-\nu)c_h \tag{6}$$

where $c_i = e_i(pQ_i - L_i) + (1-e_i)w$

2. Incentive Compatibility:

$$c_i = e_i(pQ_i - L_i) + (1-e_i)w \geq e_{-i}(pQ_i^F - L_i^F) + (1-e_{-i})w \tag{7}$$

A type i entrepreneur that falsely claims to be type $-i$ will operate his productive technology with probability e_{-i} and be assigned an amount of resources $\psi A_{-i}^{-\frac{1}{\alpha+b}} Q_{-i}^{\frac{1}{\alpha+\beta}} + f$ in order to produce Q_{-i} units of output. With this amount of resources, type i entrepreneur will produce $Q_i^F = \frac{A_i}{A_{-i}} Q_{-i}$ instead of Q_{-i}.[3]

3. Imperfect Enforcement:

$$\begin{aligned} L_i &\leq \phi p Q_i \qquad (8)\\ L_i^F &\leq \phi p Q_i^F \qquad (9) \end{aligned}$$

4. Participation Constraint: If an agent declines to enter a contract, he gets wage w, and consumes his endowment of consumption good, plus the return on the good, plus his wage for a total consumption of $R + w$, where $R = (1+r)$. If the agent enters the contract, an agent's expected consumption is his endowment of consumption good, plus the return on the good, plus the entrepreneur's expected return for a total consumption of $R + c^e$. The participation constraint is therefore

$$\nu c_l + (1-\nu)c_h \geq w \tag{10}$$

[3] An entrepreneur's cost of production is capped by the funds given to him by the intermediary. An entrepreneur that misrepresents his type is given funds $\psi_i Q_{-i}^{\frac{1}{\alpha+\beta}} + f$ but his real production costs are $\psi_{-i}(Q_i^F)^{\frac{1}{\alpha+\beta}} + f$. Making these two equal yields $Q_i^F = \frac{A_i}{A_{-i}} Q_{-i}$. The contract will be such that $pQ_h - L_h \geq pQ_l - L_l$ so that high skill would never want to pretend to be low skill and make payment as if he is low skill.

5. Feasibility:
   By the law of large numbers, each financial intermediary faces a fraction ν of low-skilled entrepreneurs and a fraction $(1-\nu)$ of high-skilled entrepreneurs. Intermediaries obtain funds from all agents in the economy and pay them back a return of R. The feasibility constraint says the the funds disbursed by the financial intermediary cannot be greater than the total endowment in the economy, $\eta = 1$.

$$\nu e_l(\psi A_\ell^{-\frac{1}{a+b}} Q_\ell^{\frac{1}{a+b}} + f) + (1-\nu)e_h(\psi A_h^{-\frac{1}{a+b}} Q_h^{\frac{1}{a+b}} + f) \leq \eta \tag{11}$$

   External funds have to be fully repaid at the end of the period,

$$\eta R = \nu e_l L_l + (1-\nu) e_h L_h \tag{12}$$

Together, the feasibility constraint becomes

$$\nu e_l(\psi A_\ell^{-\frac{1}{a+b}} Q_\ell^{\frac{1}{a+b}} + f) + (1-\nu)e_h(\psi A_h^{-\frac{1}{a+b}} Q_h^{\frac{1}{a+b}} + f) \leq \eta \leq \frac{\nu e_l L_l + (1-\nu) e_h L_h}{R} \tag{13}$$

Optimal Contract

Since the goal of the intermediary is to maximize agents expected consumption, the contract specifies that all projects run at their profit-maximizing size $\bar{Q}_i$ and all credit rationing is done by restricting the number of projects in operation. The first best scenario dictates that all resources are allocated to the high return technology, thus $e_l = 0$ and $e_h > 0$. However, this is not feasible when productivity type is unobservable since low productivity entrepreneurs have an incentive to misrepresent their type. Thus we focus on the low-productivity types.

Suppose $e_l = 0$. From the incentive compatibility constraint, a low-productivity type does not have an incentive to misrepresent his type if

$$e_l(pQ_l - L_l) + (1-e_l)w \geq e_h(pQ_l^F - L_l^F) + (1-e_h)w \tag{14}$$

$$w \geq e_h(pQ_l^F - L_l^F) + (1-e_h)w \tag{15}$$

A low-productivity entrepreneur that lies obtains output $Q_l^F = \frac{A_l}{A_h}\bar{Q}_h$. To deter lying, it is optimal to set the punishment for lying as high as possible,

$$L_l^F = \phi p Q_l^F = \phi p \frac{A_l}{A_h} \bar{Q}_h \tag{16}$$

It is clear that for high enough ϕ punishment is such that agents never lie and the first best outcome is achieved. I call $\hat{\phi}$ the threshold level such that for $\phi > \hat{\phi}$ all information is revealed and the first best outcome is achieved.

Combining (15) and (16) one gets the threshold wage for the incentive compatibility to bind.

$$
\begin{aligned}
w &\geq pe_h \frac{A_l}{A_h} \bar{Q}_h (1-\phi) + (1-e_h) w && (17) \\
\hat{w} &\geq p \frac{A_l}{A_h} \bar{Q}_h (1-\phi) && (18)
\end{aligned}
$$

Let $L_l = \chi p Q_l$, where $\chi \in (0, \phi)$ is some amount collected from low skill entrepreneurs. Rearranging the incentive compatibility constraint (7) one gets the main result from the contract.

$$
\frac{e_h}{e_l} = \frac{(1-\chi) p \bar{Q}_l - w}{(1-\phi) \frac{A_l}{A_h} p \bar{Q}_h - w} \tag{19}
$$

From here we recover observation 2: Poor countries are characterized by the use of inefficient technologies.

Proposition 1 *For $w < \hat{w}$ or $\phi < \hat{\phi}$, the ratio of good to bad projects is increasing in the enforcement parameter, ϕ. For $w \geq \hat{w}$ or $\phi \geq \hat{\phi}$, the first best outcome is achieved.*

The solution for the rest of the contract is in Appendix A.

4 Aggregation

4.1 Firm Aggregation into an Industry's Representative firm

Our goal now is to verify that industry output can be aggregated to a the output of a representative firm and find an expression for industry output. To make the notation easier, let the $\pi_{lj} \equiv \nu e_{lj}$ be the proportion of low productivity projects operated in industry j, and $\pi_{hj} \equiv (1-\nu) e_h$ be the proportion of high projects operated in industry j. Notice that weights need not add up to one. The derivation of the following expression is in the Appendix. Let $Q_j = \sum_i \pi_{ij} Q_{ij}$, $X_j = \sum_i \pi_{ij} X_{ij}$ and $N_j = \sum_i \pi_{ij} N_{ij}$. Then

Proposition 2 *Output of industry j, Q_j, is given by*

$$
Q_j = \left(\sum \pi_{ij} A_i^{\frac{1}{(1-\sigma)(1-\gamma)}} \right)^{(1-\sigma)(1-\gamma)} (N_j^{\gamma})^{1-\sigma} X_j^{\sigma} \tag{20}
$$

where $i \in \{low, high\}$.

4.2 Industry Aggregation into Aggregate Output

At each point in time there are $2J$ goods produced: J final goods and J intermediate goods.

Aggregate output $Q = \sum_j Q_j$ is given by the sum of industry output in the economy. Individual output Q_j can be used used either as a final good or as an intermediate good

$$
c_j + z_j = Q_j \tag{21}
$$

Aggregating the final goods into a single final good using a Dixit-Stiglitz aggregator give us an expression of GDP in this economy

$$Y = \left(\sum_j c_j^{\theta} \right)^{1/\theta} \tag{22}$$

Intermediate goods also aggregate in a CES fashion

$$X = \left(\sum_j z_j^{\rho} \right)^{1/\rho} \tag{23}$$

For simplicity and tractability, I assume that the same combination of intermediate goods is used to produce each variety (though potentially in a different quantity).

$$\sum_j X_j \leq X \tag{24}$$

To get an expression for TFP, the expenditures on intermediate goods needs to be subtracted.

Before defining the competitive equilibrium, it is convenient to specify the optimization problems. In what follows, I take the prices of the final good as the numeraire.

Final Sector Problem

The final sector is perfectly competitive, takes prices $\{p_j\}$ as given and maximizes profits

$$\max_{\{c_j\}} \left(\sum_j c_j^{\theta} \right)^{1/\theta} - \sum_j p_j c_j \tag{25}$$

Intermediate Sector Problem

The intermediate sector is perfectly competitive, takes prices $\{p_j\}$ and q as given, and maximizes profits

$$\max_{\{z_j\}} \; q \left(\sum_j z_j^{\rho} \right)^{1/\rho} - \sum_j p_j z_j \tag{26}$$

Industry j's Problem

Taking all prices as given, the representative firm in industry j solves the maximization problem

$$\max_{N_j, X_j} p_j Q_j(N_j, X_j) - wN_j - qX_j \tag{27}$$

With this in mind, now we can define the competitive equilibrium

Definition 1 *A competitive equilibrium consists of allocations* $\{c_j\}$, $\{z_j\}$, N_j, X_j *and prices* $\{p_j\}$, q, w *such that*

1. $\{c_j\}$ *solves the final sector problem*
2. $\{z_j\}$ *solves the intermediate sector problem*
3. N_j *and* X_j *solve industry j's problem*
4. $\{p_j\}$ *clear the gross goods market,* $c_j + z_j = Q_j\ \forall j$
5. q *clears the intermediate goods market,* $\sum_j X_j = X$, *where supply of intermediate goods is given by* $X = \left(\sum_j z_j^{\rho}\right)^{1/\rho}$
6. w *clears the labor market,* $\sum_j N_j = N$ *where labor supply* $N = \frac{1}{J}\sum_j \left(\nu(1-e_{lj}) + (1-\nu)(1-e_{hj})\right)$
7. *The final goods market clears,*
$$C = Y$$
where $C = R + \frac{1}{J}\sum_j c_j^e$ *and* $Y = \left(\sum_j c_j^{\theta}\right)^{1/\theta}$

Notice the last market clearing condition is redundant by Walras' Law. We are ready to get an expression for GDP in the competitive equilibrium, which is the main result of this part of the paper. The derivation is in the Appendix.

Proposition 3 *GDP in the competitive equilibrium is*

$$Y = \left[(1-\sigma)\sigma^{\frac{\sigma}{1-\sigma}}(S_{\theta}^{1-\sigma}S_{\rho}^{\sigma})^{\frac{1}{1-\sigma}}\right]N^{\gamma} \tag{28}$$

where aggregate TFP is everything in between square brackets and

$$S_{\rho} \equiv \left(\sum_j \zeta_j^{\frac{\rho}{1-\rho}}\right)^{\frac{1-\rho}{\rho}} \tag{29}$$

S_{θ} *is defined in an analogous way to* S_{ρ} *and*

$$\zeta_j \equiv \left(\sum \pi_{ij} A_i^{\frac{1}{(1-\sigma)(1-\gamma)}}\right)^{(1-\sigma)(1-\gamma)} \tag{30}$$

The lower the imperfect contract enforceablity parameter ϕ, the lower the weighted power mean of productivities, and this gets amplified by $\frac{1}{1-\sigma}$. Suppose for simplicity that $\rho = \theta$ so that both final and intermediate goods are equally complementary. Then $S_{\theta} = S_{\rho} = S$, the part of weighted power mean becomes $S^{1-\sigma}S^{\sigma} = S$, and it is clear that this distortion gets amplified by $\frac{1}{1-\sigma}$.

Compare this to the standard growth model with labor and capital. The only difference between intermediate goods and capital in the short run is that capital only partially depreciates every period, while intermediate goods are fully used up during the period. In the long run, intermediate goods and capital are indistinguishable. Most importantly, both capital and intermediate goods are *produced factors of production*. To appreciate why intermediate goods generate larger income per capita differences than the standard model, suppose X stands for capital alone with a capital goods share of $\frac{1}{3}$. Distortions are then amplified by $\frac{1}{1-1/3} = 3/2$. A 2-fold difference in distortions imply a $2^{3/2} = 2.8$- fold difference in income per capita. Now take the interpretation that X stands for both capital and intermediate goods. This would be the case if aggregate output is $Y = (TFP)(K^{\alpha_K} N^{1-\alpha_K})^{(1-\alpha_I)} I^{\alpha_I}$ where K stands for capital, I stands for intermediate goods, and α_K, α_I stand for capital share of final output and intermediate goods share of gross output, respectively. This is equivalent to the expression in (28) with $\sigma = \alpha_k(1 - \alpha_I) + \alpha_I$. An intermediate goods share of 1/2 of gross output and a capital share of 1/3 imply a σ of 2/3 ($\sigma = \alpha_k(1 - \alpha_{int}) + \alpha_{int} = 1/3 * (1 - 1/2) + 1/2$). Therefore a 2-fold difference in the weighted power mean now implies a $2^3 = 8$- fold difference in income per capita.

The intuition behind the multiplier is simple. Any distortion to intermediate goods not only affects the intermediate goods producer, but also to the buyer of the intermediate good all the way up the supply chain. This result is reminiscent of the "zero tax on intermediate goods" result from Diamond and Mirrlees (1971), and for pretty much the same reasons. A simple example might make it even more transparent. Suppose output is produced with only intermediate goods, $Y_t = \bar{A} X_t^{\sigma}$, and intermediate goods are themselves produced with a fraction $\bar{x}$ of output from the previous period, $X_t = \bar{x} Y_{t-1}$. In steady state, output is then $Y^* = \bar{A}^{\frac{1}{1-\sigma}} \bar{x}^{\frac{\sigma}{1-\sigma}}$. A distortion in TFP affects output $\bar{A}^{1+\sigma+\sigma^2+\cdots} = \bar{A}^{\frac{1}{1-\sigma}}$. This is the same result we get from the Solow model with no labor and calling X capital and $\bar{x}$ the savings rate.

5 Discussion

Going back to observations 1 and 3, let's show how the model delivers them endogenously. Observation 1 referred to the fact that in poor countries, industries with high labor returns employ less people than industries with high labor returns. The next proposition is a formal statement of this observation, whose proof is in the Appendix.

Proposition 4 *For enforcement parameter $\phi < \bar{\phi}$ and for $w < \bar{w}$ industry efficiency is decreasing in industry fixed setup cost while industry employment is increasing in fixed setup cost.*

The intuition is the following. The higher the fixed cost, the more binding the incentive compatibility and the participation constraint, which lowers ratio of good to bad projects. This happens because the intermediary needs to increase the return of low skill agents in order to give them an incentive not to lie. This also implies that average returns (profits of firms) is higher since the entry restrictions are the most binding. This in turn implies that return to labor inputs are highest, but employment doesn't flow there because expansion can only be done through entry of new firms (decreasing returns) and entry is restricted, because agents can't commit to pay for loans.

Notice how barriers to factor mobility are at the heart of the cause of the distortion. Without this barrier, returns to labor would be equalized across industries which could only happen in the case where profits are equalized across industries. Therefore the observation of inefficient use of technologies and greater dispersion of labor productivity are inseparable in this model. Also, this would not be much of a problem if the majority of resources (labor) was employed in the industry with highest returns to labor. The result that it is the industry with lowest returns to labor that employs most of the workforce is also essential in making sense of the nature of the distortion.

Finally, let's discuss observation 3: the price of intermediate goods is higher in poor countries. For now I have not proven this but my intuition is the following. As long as intermediate goods are more complementary than final goods, the distortion will be felt harder in the intermediate goods sector as the average producivity of this sector will be more dependent on the weakest industry. This, in turn, will affect the supply of the intermediate good while its demand is unchanged, and its price will increase through the conventional supply and demand argument. A formal proof will be provided in subsequent versions of this paper.

6 Taking the Model to the data

To come.

Appendix A Optimal Contract

First, recall that output Q_l and Q_h are at their profit mazimizing levels. Next, notice both the incentive compatibility for low type and the feasibility constraint will bind, since returns to projects are positive. Combining the incentive compatibility and the feasibility constraint at equality, however, leaves the ratio of good to bad projects undetermined. Therefore the planner will allow entry as long profits for low type are zero ($pQ_i - wN_i - qX_i - w = 0$). This determines e_l. $L_l = \chi p Q_l$ is determined by the equalization of the incentive compatibility constraint for low type and the feasibility constraint. e_h is determined by equation (18). Finally, to prevent high types to have an incentive to be low types, the payment by high type is given by

$$L_h = \begin{cases} min\{\phi p Q_h,\, pQ_h - w\} \text{ if } pQ_h - L_h > pQ_l - L_l \\ pQ_l - L_l - pqX_h \text{ otherwise} \end{cases} \tag{31}$$

This says that if the high type is strictly better off being a high type, then the intermediary wants to charge the high type as high as possible in order to fund as many projects as possible. ‘As high as possible’ means it should not violate the high type’s participation constraint. Otherwise, the high type is charged just enough so that he is indifferent by claiming to be low type or high type. At indifference, I assume a type always reports truthfully.

The discrete nature of the repayment schedule is due to the linearity of the objective function for the intermediary.

Appendix B Proof of Proposition 2: Industry Output

This section derives industry output for a generic number of inputs. Industry subscript j is ignored for ease of exposition, with the understanding that all allocations are industry-specific.

Individual i is endowed with production function Q_i, which takes M inputs and combines them with a Cobb-Douglas technology

$$Q_i(\mathbf{x}) = A_i \prod_{m=1}^{M} x_{im}^{\alpha_m} \tag{32}$$

where $\alpha \equiv \alpha_1 + \alpha_2 + ... + \alpha_M < 1$. Denote the price of input $x_{i,m}$ by w_m and the price of output by p. The first order conditions from the firm’s problem is

$$p\frac{\alpha_m}{x_{i,m}} Q_i(\mathbf{x}) = w_m, \quad \forall m \tag{33}$$

The ratio between any two marginal products is

$$\frac{x_{i,m}}{x_{i,n}} = \frac{\alpha_m w_n}{\alpha_n w_m} \tag{34}$$

Substituting back into the first order conditions, one gets unconditional factor demand

$$x_{i,m}(p,\mathbf{w}) = p^{\frac{1}{1-\alpha}} \frac{\alpha_m}{w_m} \left(\frac{B}{W}\right)^{\frac{1}{1-\alpha}} A_i^{\frac{1}{1-\alpha}} \tag{35}$$

where $B \equiv \prod_{m=1}^{M} \alpha_m^{\alpha_m}$ and $W \equiv \prod_{m=1}^{M} w_m^{\alpha_m}$. Define $x_m = \sum_i x_{i,m}\pi_i$ and $Q = \sum_i Q_i \pi_i$, where π_i is the fraction of projects of type i that are operated.

Aggregate equation (?)

$$x_m(p,\mathbf{w}) = p^{\frac{1}{1-\alpha}} \frac{\alpha_m}{w_m} \left(\frac{B}{W}\right)^{\frac{1}{1-\alpha}} \sum_i A_i^{\frac{1}{1-\alpha}} \pi_i \tag{36}$$

and manipulate equation it to get

$$w_m^{-1} \left(\frac{p}{W}\right)^{\frac{1}{1-\alpha}} = x_{i,m}(\alpha_m B)^{-\frac{1}{1-\alpha}} \left(\sum_i A_i^{\frac{1}{1-\alpha}} \pi_i\right)^{-1} \tag{37}$$

Substitute back in (?),

$$x_{i,m}(p,\mathbf{w}) = x_m \frac{A_i^{\frac{1}{1-\alpha}}}{\sum_i A_i^{\frac{1}{1-\alpha}} \pi_i} \tag{38}$$

Plugging back into the individual production function yields

$$Q_i = A_i^{\frac{1}{1-\alpha}} \left(\sum_i A_i^{\frac{1}{1-\alpha}} \pi_i\right)^{-\alpha} \prod_{m=1}^{M} x_m^{\alpha_m} \tag{39}$$

Aggregating one last time we find the expression for industry output,

$$Q = \left(\sum_i A_i^{\frac{1}{1-\alpha}} \pi_i\right)^{1-\alpha} \prod_{m=1}^{M} x_m^{\alpha_m} \tag{40}$$

Appendix C Cost Function and Output for a Generic Number of Inputs

From the first order condition (23)

$$x_{i,m} = \frac{\alpha_m w_1}{\alpha_1 w_m} x_{i,1} \tag{41}$$

to produce output

$$A_i \prod_{m=1}^{M} x_{i,m}^{\alpha_m} = y_i \tag{42}$$

substituting from (30)

$$y_i = A_i \left(\frac{w_1}{\alpha_1}\right)^{\alpha_1} \left(\frac{B}{W}\right)^{1/\alpha} x_{i,1}^{\alpha} \tag{43}$$

with B and W as defined in appendix A. Rearranging and substituting in (30) yields

$$x_{i,m}(\mathbf{w}, y_i) = \frac{\alpha_m}{w_m} \left(\frac{W}{B}\right)^{1/\alpha} A_i^{-1/\alpha} y_i^{1/\alpha} \tag{44}$$

With cost function $C(\mathbf{w}, \mathbf{x}_i) = \sum_{m=1}^{M} x_{i,m} w_m + f$, the cost function becomes

$$C(\mathbf{w}, y_i) = \alpha \left(\frac{W}{B}\right)^{1/\alpha} A_i^{-1/\alpha} y_i^{1/\alpha} + f \tag{45}$$

To find output, plug the cost function into the firm problem and maximize to get

$$y_i = p^{\frac{\alpha}{1-\alpha}} \left(\frac{W}{B}\right)^{-\frac{1}{1-\alpha}} A_i^{\frac{1}{1-\alpha}} \tag{46}$$

Appendix D Derivation of GDP in the competitive equilibrium

To be provided. A similar proof can be found in the appendix of Jones (forthcoming).

Appendix E Proof of Proposition 4

This proof can be found in Erosa and Cabrillana (2008).

Appendix F Profits in the model

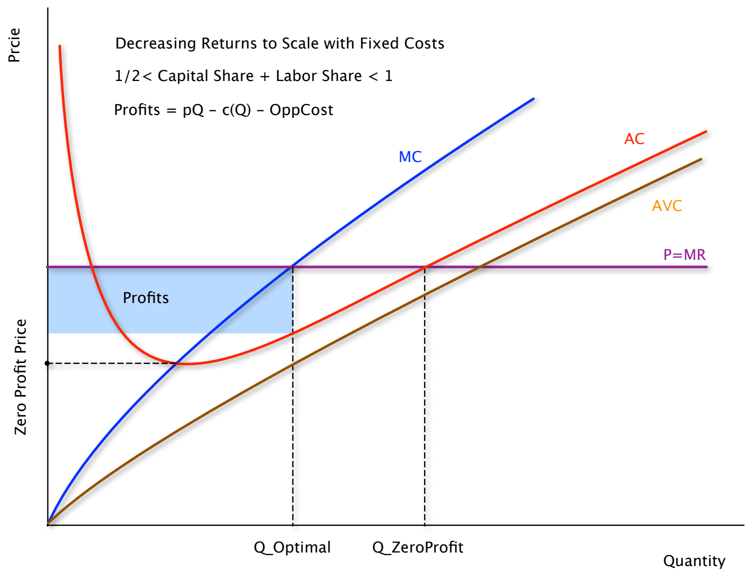


Figure 1: Decreasing Returns to Scale with Fixed Costs: Optimal Size and Positive Profits

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