Misallocation, Informality and Human Capital

Pablo N D’Erasmo * Hernan J Moscoso Boedo †
University of Maryland University of Virginia

Aslı Şenkal ‡
University of Virginia

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Abstract

There is a considerable gap between the stocks of human capital between the advanced and the developing world. In this paper, we develop a theory of total factor productivity with heterogeneous firms, to explain the differences in the stock of human capital across countries. In our model firms operate in an economy with capital markets imperfections and costs of creating and operating in the formal sector. These distortions give rise to endogenous formal and informal sectors where firms face a technology adoption opportunity. While formal firms have a larger set of production opportunities, informal firms can avoid the operating costs. The model predicts that countries with a low degree of debt enforcement and high costs of formality are characterized by low allocative efficiency and a larger informal sector, lower TFP and lower human capital accumulation. We find that this mechanism is important in generating the skill distribution observed in developing countries.

Keywords: Financial Structure, Informal Sector, Productivity, Policy Distortions, Human Capital.

JEL Classifications: D24, E26, L11, O16, O17

*Correspondence: University of Maryland, Department of Economics, 3105 Tydings Hall, College Park, MD 20742, (301)405 3529, derasmo@econ.umd.edu
†Correspondence: University of Virginia, Department of Economics, PO Box 400182, Charlottesville, VA 22904, (434)924 7654, hmoscoso@virginia.edu
‡Correspondence: University of Virginia, Department of Economics, PO Box 400182, Charlottesville, VA 22904, as7av@virginia.edu
1 Introduction

There is a considerable discrepancy in human capital stocks between the developed and the developing countries. Although developing countries had a significant improvement in educational attainment since 1960, there still remains a considerable gap between the developing and the advanced world. Barro and Lee (2001) document that for the year 2000, that 37% of the population aged over 25 and over have no formal schooling and only 27% have some secondary education in the developing world. On the other hand, in advanced and transition economies about two-thirds of the population aged over 25 have some secondary education. Figure (1a) shows the positive correlation between GDP per capita and skills.\textsuperscript{1}

Jones and M. Romer (2009) document that differences in measured inputs explain less than half of the immense cross country differences in per capita GDP. It is of great importance to explain what gives rise to the TFP distribution across countries. The strong positive relationship between GDP and TFP is displayed in Figure (1b). Our aim in this paper is two-fold. First, we test whether the measured costs of doing business lead to TFP differences across countries. Second, we analyze whether differences in TFP lead to differences in the stock of human capital across countries?

As Figure 2 shows, informal activity is correlated with productivity and the stock of human capital. As a measure of informality, we use the fraction of the labor force that participates in the underground economy. Agents involved in the informal sector make explicit efforts not to be detected, which makes measuring the informal sector extremely challenging.\textsuperscript{2} The fraction of the labor force that is engaged in production outside of the formal sector ranges from around 10\% in developed countries to almost 100\% at the low end of the income distribution. Although the measures of informality are extremely noisy, such a large sector of the economy cannot be ignored when analyzing the differences in economic development around the world. Figure (2a) relates the human capital stock to the informal labor force.\textsuperscript{3} This relation is also supported by microdata. We

\textsuperscript{1}Skills are defined as the percentage of people that completed college as a percentage of the population over age 25, taken from Barro and Lee (2001).

\textsuperscript{2}Measured as the fraction of the labor force not covered by a pension scheme. We focus on the share of labor force not covered by pension schemes because it provides a better direct measure of informality for the US, the country we use for our benchmark calibration.

\textsuperscript{3}Informal labor force is measured by the share of the labor force that is not covered by a pension scheme, WDI
Figure 1: Skills, Total factor productivity and GDP per capita
Note: Skills are defined as the percentage of people that completed college as a percentage of the population over age 25, taken from Barro and Lee (2001). Total factor productivity and output per effective worker are authors calculations based on Hall and Jones (1999). See appendix for details. Solid lines indicate OLS regression.

make the assumptions about the production possibilities of the two sectors following Pratap and Quintin (2008), where they report that informal sector is characterized by small scale, unskilled and self-financed activities. Funkhouser (1996) in a cross-country study of 5 Latin America countries also shows that mean education level in the formal sector is substantially higher than the mean education level in the informal sector, and this difference is even higher for the female workers.

To answer the above questions, we build a firm dynamics model with endogenous entry and exit that incorporates capital and bankruptcy decisions by adding human capital to Moscoso Boedo and D’Erasmo (2010). In the presence of institutional frictions, the model generates endogenous formation of the formal and the informal sectors for firms. The formal sector is characterized by better access to credit markets due to better commitment, but it is costly due to taxes. The formal sector also has a larger set of production possibilities with a higher mean productivity, and can also employ skilled labor, whereas the informal sector can only use unskilled labor with (2006). Size of the informal activity varies according to the measure used, see Schneider and Enste (2000) for direct and indirect approaches in calculating informal activity.
lower productivity. The market imperfections we adopt include entry costs to the formal sector, distortionary taxes, and inefficiency in enforcing debt mechanisms. These trade-offs generate the sorting into formal and the informal sectors. The mechanism is as follows: Due to these frictions stated above in the formal sector, given their productivity draws some firms choose to operate in the informal sector and use an inferior technology which leads to capital misallocation, and lower measured TFP compared to the frictionless benchmark case. Higher the distortions in the economy the larger the informal sector, which leads to less human capital accumulation. Introducing cross country institutional differences leads to capital misallocation and these frictions explain more than two-thirds of the TFP differences between US and developing economies, while being consistent with the skill distribution across countries.

Amaral and Quintin (2008) in a theoretical model with endogenous informal sectors and endogenous sorting of managers with differential abilities that result from imperfect contract enforcement, and institutional frictions show that formal sector puts a greater emphasis on skilled labor in the formal sector. This paper builds on this literature by analyzing a model of firm dynamics with
idiosyncratic uncertainty, endogenous technology adoption and endogenous human capital formation. We also consider different financial contracts where default costs are constrained by limited liability.

As in Rauch (1991) and Loayza (1996), in our model informal sector is an optimal response to the economic environment. Similarly, Amaral and Quintin (2008) in a theoretical model with an endogenous informal sector and endogenous sorting of managers with differential abilities, show that formal sector puts a greater emphasis on skilled labor. In this paper, we contribute to this literature by quantitatively measuring the effects of frictions and informality on the stock of human capital.

Our approach to firm dynamics originates with Hopenhayn (1992) and Hopenhayn and Roger-son (1993), and we add capital markets as in Cooley and Quadrini (2001) to our model.

Recent related literature on the distributional consequences of frictions follows two approaches in measuring the institutional and financial frictions. Hsieh and Klenow (2009), Restuccia and Rogerson (2008), Guner, Ventura, and Xu (2008), Arellano, Bai, and Zhang (2009) and Buera, Kaboski and Shin (2009) back up the implied frictions that firms face to generate the observed distribution of the firms. The second strand of the literature uses the measured frictions documented by the Doing Business data set as in this paper. Papers in this group include Barseghyan and DiCecio (2010), Moscoso Boedo and DErasmo (2010) and Moscoso Boedo and Mukoyama (2010).

We first calibrate our model to the US economy. Since the model is computationally intensive we divide the countries into 3 groups, the high income, upper middle income, lower middle income and low income economies. Taking the US economy as the benchmark, we introduce the frictions for our 3 groups of countries to see the impact of these frictions on the skill distribution through TFP.

The remainder of the paper is organized as follows, section 2 describes the data, section 3 presents the model, section 4 presents the equilibrium, section 5 explains the calibration for the benchmark case without frictions, section 6 presents the results with frictions for the high income, middle income and low income countries and section 7 concludes.
2 Data

We use the World Bank Doing Business data set to measure the institutional frictions, which provides a quantitative measure of regulations for starting a business, dealing with construction permits, employing workers, registering property, getting credit, protecting investors, paying taxes, trading across borders, enforcing contracts and closing a business both in terms of time and resources. In this paper, we will focus on the cost of entering the formal sector, the tax rate and the level of tax compliance difficulty (while operating in the formal sector), and the efficiency of the debt enforcing mechanisms if the firm decides to default on its debt. Figure (3) provides the data on these frictions across countries.

The cost of entering the formal sector is constructed as in Moscoso Boedo and Mukoyama (2010). It includes the costs of registering a business and of dealing with licences to operate a physical locale. Both costs have a monetary cost and a time cost (which is translated to monetary units by assuming that one worker has to be employed full time in order for the firm to go through the entry process). The cost of entering the formal sector as a fraction of the wage (denoted by \( \omega \kappa \)) varies greatly across countries, with high levels of \( \kappa \) observed only at the low end of the income distribution. For example, registering a business in the developed countries like US and UK costs only 0.7% of GNI per capita, while in Argentina and Turkey this cost is 9.0% and 14.9% respectively, whereas in Zimbabwe it is 500% of GNI per capita. In terms of time, starting a formal business takes more than 4 years in Zimbabwe, more than 1.5 years in Brazil and only 46 days in US. Dealing with licenses also displays great variation across countries. The cost is 13% of GNI per capita in the US and 600 times per capita income in Liberia and 100 times in Zimbabwe. In terms of time, it takes 40 days to obtain a license in the US and up to 1000 days in Haiti.

In terms of the tax structure we concentrate on payroll taxes, profit taxes and the cost of tax compliance. The tax rate paid on profits, pay roll taxes and cost of tax compliance are respectively denoted by \( \tau \), \( \tau_{\omega} \) and \( \omega_{nC}\tau \). Cost of tax compliance reflects the time that it takes to pay taxes

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4. includes all procedures required for a business in the construction industry to build a standardized warehouse.
5. The data used to generate the cost of dealing with licenses to operate a physical local is obtained from the World Bank Doing Business database as Dealing with Construction Permits. Part of the elements involved in construction permits, such as the cost of connection to basic services, are present when operating a physical locale.
Figure 3: Cost to entry, income tax rate, cost of tax compliance, recovery rate, and cost of default proceedings from the Doing Business Database in 2009.
in each country. We assume that there is a full time unskilled worker during this time devoted to the tasks related to tax compliance, and therefore translate time into costs as the workers annual wages. The cost of paying taxes only displays levels above 10 weeks for countries below 20% of the US GNI per capita. Paying taxes takes no time in the Maldives, 12 hours in the UAE, 187 hours in the US, and more than 1000 hours in Vietnam, Bolivia, Belarus, Cameroon and Brazil.

The efficiency of the system in the event of default has two components, a cost component and a recovery rate. The cost of the system $\phi$, reported as a percentage of the estates value, includes court fees and the cost of insolvency practitioners, such as legal and accounting fees. It ranges from 1% of the estates value in countries like Norway and Singapore to more than 40% in Sierra Leone, Liberia, and the Ukraine and above 70% in the Central African Republic. The recovery rate $\lambda$ refers to what external lenders obtain once the firm decides to default on its debt. It is effectively zero for many extremely poor countries in sub-Saharan Africa, and over 75% in most of the developed economies. For example in US this rate is 76.7%, whereas in Turkey it is 20.2%, 29.8% in Argentina, and 0.0% in Zimbabwe.

Our main goal is to match the cross country skill distribution in this paper, so the definition of skills is crucial. It is hard to find an accurate and comprehensive cross country distribution of skills, since schooling quality might differ significantly across countries. Data on education is taken from Barro and Lee (2001). This data set provides the largest coverage for cross country education attainment up to 1995 and also construct projections to 2000. They fill the missing observations by the perpetual inventory method using the enrollment ratios. The data contains educational attainment data for primary, secondary and higher level of education for both completed and not completed for the population over age 25, and the average years of schooling. We assume that every agent is born with primary school education. An agent becomes skilled after college completion, which takes 6 years. The skilled individuals as a fraction of the total population is 30.03% in US according to our definition of skills, with the highest level stock of human capital. The lowest level of human capital is at Mozambique with 0.1%. Informal labor force data is taken from World Bank Development Indicators (WDI) database (2006), which measures the percentage of the labor force which is not covered by the pension scheme.
3 Environment

We build a firm dynamics model augmenting D’Erasmo and Moscoso Boedo(2010) with human capital. The model is based on Hopenhayn (1992) and incorporates capital and credit markets as in Cooley and Quadrini (2001). Time is discrete, and we set one period to be one year. There are three kinds of entities in the economy: firms, lenders and consumers. Firms produce the consumption and capital goods used in the economy. They are the capital owners and pay dividends to the consumers. The firm chooses formal or the informal sector to operate in given the technology, fixed cost draws and institutional distortions. Lenders make loans to firms given the capital, debt and the productivity level of the firms. Consumers supply both skilled and unskilled labor to the firms. They also receive their profit net of entry costs. We focus on the stationary equilibrium.

3.1 Consumers

There is an infinitely lived representative consumer who maximizes the expected utility:

$$U = E \left[ \sum_{t=0}^{\infty} \beta^t u(C_t) \right]$$

(1)

where $E$ is the expectation operator, $C_t$ is consumption and $\beta \in (0, 1)$ is the discount factor. The household is endowed with one unit of labor, where she can either work as a skilled or an unskilled worker. Since we concentrate on the stationary equilibrium, aggregates in the economy are constant. This, and the fact that the consumer supplies its unit of labor inelastically, implies that the consumer maximizes expected discounted utility subject to the following budget constraint:

$$C = \omega_n n + \omega_s s + \Pi + T - E + X$$

(2)

where $\Pi$ is the total profit, $T$ is the lump-sum transfer from the income and payroll taxes, $E$ is the aggregate creation cost, and $X$ is the exit value of firms. Note that the consumer is not making any decisions, only receiving transfers, profits, and wages which are consumed period by period.
We assume that skills are acquired through home schooling. The agent can choose to remain outside the market for $x$ years, and then becomes a skilled worker. The wage rate for the skilled workers is denoted by $\omega_s$ and the wage rate for the unskilled worker is $\omega_n$. The benefit to schooling is:

$$\beta^{x+1} \sum_{t=0}^{\infty} [\omega_s \beta^t (1 - \delta_s)^t]$$

where $\delta_s$ is the depreciation rate of skilled labor. The cost of schooling is the foregone wages for $x$ years

$$\sum_{t=0}^x \beta^t \omega_n$$

which gives the following equilibrium condition for the skill premium.

$$\frac{\omega_s}{\omega_n} = \left[ \frac{1 - \beta (1 - \delta_s)}{1 - \beta} \right] \frac{1}{\beta^{x+1}}$$

The law of motion for human capital is as follows:

$$s_{t+1} = (1 - \delta_s)s_t + (1/x)S_t$$

where $S_t$ is the number of students.

The skilled worker receives the wage rate $\omega_s$, and the unskilled worker receives the wage $\omega_n$ and receives the profits of the operating firms and a lump sum transfer from taxes collected on these firms. The consumer is also responsible for the creation cost of new firms. All the saving and borrowing decisions are made by firms, so effectively the household is not allowed to borrow or save.

### 3.2 Firms

The unit of production is a single establishment firm, also understood as a unique investment project. Each project is described by a production function $f(z, k, s, n)$ that combines physical capital $k$, skilled labor $s$ and unskilled labor $n$. The production process displays decreasing returns to scale.
As mentioned earlier, empirical evidence shows that formal sector workers have higher education and earn more compared to the informal sector workers. We assume that the formal sector technology is given by:

\[ f(z, k, s, n) = zk^\alpha s^\epsilon n^\gamma \]  \tag{6}

The informal sector technology is given by

\[ f(z, k, s, n) = zk^\alpha n^\gamma \]  \tag{7}

\( z \) is the exogenous technology shock. There are two processes for \( z \): one whose used is limited to the formal sector (l), and one unlimited with regards to sectors (u). The limited productivity process is given by,

\[ \ln(z_{t+1}) = (1 - \rho) \ln(\mu_l) + \rho \ln(z_t) + \varepsilon_{t+1} \]  \tag{8}

with \( \varepsilon_{t+1} \sim N(0, (1 - \rho^2)\sigma^2) \) where \( \sigma^2 \) is the variance of \( \ln(z) \), \( \mu_l \) is the mean and \( \rho \) is the auto-correlation parameter of the process. The conditional distribution of \( z_{t+1} \) is denoted as \( \eta_l(z_{t+1}, z_t) \).

The unlimited productivity process is assumed to be a constant given by \( \mu_u \). These two processes are calibrated to match the size distribution of formal firms and the size of the informal sector.

Firms maximize expected discounted dividends \( d \):

\[ E \sum_{t=0}^{\infty} \beta^t d_t \]  \tag{9}

at the rate of the representative consumers \( \beta \).\(^6\)

Firms can be created by paying a cost \( c_e \) either formal or informal. After paying this cost, firms learn their initial level of productivity \( z_{0,j} \) for each technology. Their initial level of productivity \( z_{0,j} \) is drawn from the distribution \( \nu_j(z_0) \). Draws from this distribution are assumed to be i.i.d across firms and technologies. After observing their productivity, firms choose between staying out of the market or operating one of the technologies as a formal or an informal firm.

\(^6\)We only discuss the stationary equilibrium of the model, so we omit the stochastic discount factor.
There is a random fixed cost of production $c_f$, measured in units of output, that is iid. across firms and over time with distribution $\xi(c_f)$ paid every period both in the formal and the informal sector. Establishments own their capital and can borrow from financial intermediaries in the form of non-contingent debt $b \geq 0$. They finance investment with either debt or internal funds. The problem of the formal sector incumbent, informal sector incumbent, and the entrants are described below.

3.2.1 Formal Sector Incumbent

An incumbent establishment in the formal sector with technology $j \in l,u$ starts the period with physical capital $k$, debt $b$, and previous productivity $z_{-1}$. Then, the firm draws the fixed cost that is required for continuing the operation, $c_f$, and decides to operate the technology, exit after repayment of debts, or default and liquidate the firm. If the firm decides to exit after repayment, it receives $k - b$, if it decides to default and liquidate the firm, it receives the maximum of the remainder of the capital $(1 - \phi)k$ after paying the recovery rate $\lambda$ (net of the costs associated with default proceedings) to the outside investors and zero. The value function of an establishment at this stage is denoted as $W^f_j(z_{-1}, k, b, c_f)$. If it decides to remain in business, it pays $c_f$ and observes the current period’s productivity $z$. The value function of a firm operating in the formal sector is denoted as $V^f_j(z, k, b, c_f)$. If the firm decides to operate, it decides the amount of skilled and unskilled labor in the current period, $s$ and $n$ respectively, capital and assets for the following period, $k'$ and $b'$, and produces. The formal sector incumbent is subject to a proportional tax on profits $\tau$, a cost in unskilled labor units of filing those taxes $c_\tau \omega_n$, and a payroll tax $\tau_\omega n$ for both the skilled and the unskilled labor.\(^7\)

The incumbent solves the Bellman equation

$$W^f_j(z_{-1}, k, b, c_f) = \max \left\{ \int V^f_j(z, k, b, c_f) d\eta_j(z|z_{-1}), \max\{0, (1 - \phi)k - \lambda b\}, k - b \right\}$$

\(^7\)Most countries apply progressive taxes, the tax rates on the skilled and unskilled labor might differ. Evaluating the costs as a percentage of the unskilled wage might underestimate the frictions prevailing in the economy.
and
\[ V^f_j(z, k, b, c_f) = \max_{n, s, k', b', s} d^f_j(z, k, b, c_f) + \beta \int W^f_j(z, k', b', c_f') d\xi(c_f) \] (11)
\[ \text{s.t.} \]
\[ d^f_j(z, k, b, c_f) = (1 - \tau)[f(z, k, s, n) - c_f - \omega_n(1 + \tau_\omega)(n + \omega_s)(1 - \delta)k + q^f_j(k', b', b' - b \geq 0] \]

The solution to this problem provides the exit decision rule \( \chi^f_j(z_{-1}, k, b, c_f) \) that takes the value of 0 if the firm continues to operate, 1 if the firm decides to default, and 2 if the firm decides to exit after repayment. We also obtain the optimal capital and debt decision rules \( k'^f_j(z, k, b, c_f) \) and \( b'^f_j(z, k, b, c_f) \), respectively, for a firm in the formal sector.

3.2.2 Informal Sector Incumbent

An incumbent establishment in the informal sector, after observing the fix operating cost \( c_f \), can choose to stay informal, to pay the formal entry cost \( \kappa \omega_n \) and switch operations to the formal sector, or to exit the market after a default. More specifically, the informal incumbent establishment solves the following Bellman equation;
\[ W^i(k, b, c_f) = \max \left\{ V^i(k, b, c_f), \bar{V}^i_s(k, b, c_f), k \right\} \] (12)
where the value of staying in the informal sector is
\[ V^i(k, b, c_f) = \max_{n, k', b', s} d^i(k, b, c_f) + \beta \int W^i(k', b', c_f') d\xi(c_f) \] (13)
\[ \text{s.t.} \]
\[ d^i(k, b, c_f) = f(z, k, s, n) - c_f - \omega_n n - \omega_s s - k' + (1 - \delta)k + q^i(k', b', b' - b \geq 0] \]

The value of switching to the formal sector is
\[ \bar{V}^i_j(z, k, b, c_f) = \max_{n, s, k', b'} d^f_j(z, k, b, c_f) + \beta \int W^f_j(z, k', b', c_f') d\xi(c_f) \] (15)
\[
\tilde{d}_j^f = (1 - \tau)[f(z,k,s,n) - c_f - \omega_h(1 + \tau \omega)(n + c_\epsilon + \kappa)] - \omega_h(1 + \tau \omega)s - k' + (1 - \delta)k + q'_s(k', b', z)b' - b \geq 0
\]

The solution to this problem provides the exit decision rule \( \chi^f_j(z_{-1}, k, b, c_f) \) that takes the value of 0 if the firm continues to operate in the informal sector, 1 if the firm decides to default, and 2 if it decides to switch its operations to the formal sector. We also obtain the optimal capital and debt decision rules \( k'_s(z, k, b, c_f) \) and \( b'_s(z, k, b, c_f) \) for a firm operating in the informal sector, and capital and debt decision rules \( \tilde{k}'_s(z, k, b, c_f) \) and \( \tilde{b}'_s(z, k, b, c_f) \) for a firm that switches from the informal to the formal sector.

3.2.3 Entrants

To draw from the pool of ideas, potential entrants pay a creation cost given by \( c_e \). The value of a potential entrant \( W_e \) is given by:

\[
W_e = \int \int \max_{j=s,l} \{W^l_i(0, 0, 0), \tilde{V}_l^f(z_0, 0, 0, 0)\} d\nu_s(z_0) d\nu_l(z_0) - c_e
\]

Effectively, an entrant has no capital, no debt, and the cost of production \( c_f \) equals zero. The entrant chooses between technologies, conditional on the restriction that the limited technology cannot be operated in the informal sector. The sector and technological decision are made after paying \( c_e \) and observing the productivity level \( z_{0,l} \), which affects the conditional distribution from which the first productivity parameter will be drawn. Differences in the volatility of the process together with differences in initial productivity are going to generate differences in the decisions by the entrants and by the potential lenders. That introduces differences in behavior as a function of volatility and contract enforceability. In equilibrium, \( W_e = 0 \) will hold. The solution to this problem provides the entry decision rule \( \Xi(z_{0,u}, z_{0,l}) \).

3.3 Lenders

The credit industry makes loans to the formal and informal sector firms. Creditors are risk-neutral and competitive. Each country behaves as a small open economy where intermediaries can borrow
or lend at the exogenous risk-free rate $r$. Asset markets are incomplete. In each period, firms borrow using only one period non-contingent debt denoted by $b$. Since there is perfect information, prices depend on firms characteristics given by their choice of sector (formal or informal), their future level of capital ($k'$), their level of borrowing ($b'$), and their current technology ($z$). In particular, firms in the formal sector will borrow at price $q_f^j(k', b', z)$ and firms in the informal sector will borrow at price $q_i^j(k', b', z)$, default on their debt. A default triggers a bankruptcy procedure that liquidates the firm. If a firm defaults in the formal sector, creditors can recover up to a fraction $\lambda$ of the original loan. The formal bankruptcy procedure has an associated cost equal to a fraction $\phi$ of the firm capital. The values of the recovery rate $\lambda$ and the bankruptcy cost $\phi$ are obtained from the Doing Business database. Because the capital of the informal firm is not legally registered, the recovery rate of a loan to an informal sector firm that defaults is assumed to be zero.

Lenders make loans to formal and informal establishments and take prices as given. Profit for a loan $b'$ to a firm in the formal sector with future capital $k'$

$$
\pi_f^j(k', b', z) = -q_f^j(k', b', z)b' + \frac{1 - p_f^j(k', b', z)}{1 + r} b' + \frac{p_f^j(k', b', z)}{1 + r} \min\{\lambda b', (1 - \phi)k'\} \tag{17}
$$

where $p_f^j(k', b')$ denotes the default probability of this borrower.

Profit for a loan $b'$ to a firm in the informal sector with future capital $k'$

$$
\pi_i^f(k', b') = -q_i^f(k', b')b' + \frac{1 - p_i^f(k', b')}{1 + r} b' \tag{18}
$$

where $p_i^f(k', b')$ denotes the default probability of the informal borrower. In equilibrium, the schedule of prices will adjust so that $\pi_f^j(k', b', z) = 0$ and $\pi_i^f(k', b') = 0$ for all $(j, k', b', z)$.

4 Equilibrium

We focus on the stationary equilibrium of the model. In this equilibrium the wage rates and the schedule of loan prices are constant. Once the wage $\omega_n$ is solved for, the skill premium equation will determine $\omega_s$. Every equilibrium function depends on the set of loan prices and the wage rates.
4.1 Definition of equilibrium

A stationary competitive equilibrium is a set of value functions \( W^f_j, W^i_j, V^f_j, \tilde{V} \), decision rules (physical capital, human capital, debt, default, exit and sector), the wage rates \( \omega_k, \omega_n \) aggregate distributions of firms in the formal \( \theta(k, b, z, s, j; M) \) and informal \( \tilde{\theta}(k, b, s; M) \) sectors, and a mass of entrants \( M \) such that:

1. Given prices, the value function of the firms and the decision rules are consistent with firms optimization.
2. The free entry condition is satisfied: \( W_e = 0 \).
3. Lenders make zero profit for every type of loan.
4. Invariant distributions \( \theta \) and \( \tilde{\theta} \) are stationary.
5. Aggregate consumption \( C = \omega_n n + \omega_s s + \Pi + T - E + X \).
6. The labor market clears

\[
1 = \int (n(z,k) + s(z,k))d\nu(k, b, z, j; M) + \int (n(z,k) + s(z,k))d\tilde{\nu}(k, b; M) + S_t
\]

where \( S_t = s_t \delta_t x \)

5 Calibration

In this section we calibrate the model to the US economy. The basis for this calibration can be found in Moscoso Boedo and Mukoyama (2008) and D’Erasmo (2009). The productivity process for the limited technology is given by

\[
\ln(z_{t+1}) = (1 - \rho)\ln\mu_l + \rho \ln(z_t) + \epsilon_{t+1}
\]

with \( \epsilon_{t+1} \sim N(0, (1 - \rho^2)\sigma_l^2) \) where \( \rho \) is the autocorrelation parameter and \( \sigma_l^2 \) is the variance of the process. The volatility of the limited process \( \sigma_l \) is set to 0.2305 and the autocorrelation parameter \( \rho \) to 0.885 as estimated for the U.S. manufacturing sector by Cooper and Haltiwanger
The process is discretized to obtain the grid for $z$ and the transition probabilities $\eta_k(z'|z)$ following Tauchen (1986). From the transition matrix $\eta_l(z'|z)$ we can derive the unconditional probabilities $\eta^*_l(z)$. We set the distribution of initial shocks $\nu_l(z_0) = \eta^*_l(z)$. As a benchmark, given the lack of information about the distribution of establishments in the informal sector, we set $\sigma_z = 0$ so productivity of the simple projects is constant.

<table>
<thead>
<tr>
<th>Table 1: Model Parameters</th>
<th>value</th>
<th>moment (US economy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>discount factor</td>
<td>$\beta$</td>
<td>0.9615</td>
</tr>
<tr>
<td>depreciation rate for capital</td>
<td>$\delta_k$</td>
<td>0.07</td>
</tr>
<tr>
<td>depreciation rate for skilled labor</td>
<td>$\delta_s$</td>
<td>0.015</td>
</tr>
<tr>
<td>production function</td>
<td>$\varepsilon_f$</td>
<td>0.286</td>
</tr>
<tr>
<td>production function</td>
<td>$\alpha$</td>
<td>0.21</td>
</tr>
<tr>
<td>production function</td>
<td>$\gamma_i$</td>
<td>0.64</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>$\sigma$</td>
<td>0.2305</td>
</tr>
<tr>
<td>Autocorrelation</td>
<td>$\rho$</td>
<td>0.885</td>
</tr>
<tr>
<td>Creation Cost</td>
<td>$c_e$</td>
<td>0.095</td>
</tr>
<tr>
<td>Mean Process</td>
<td>$\mu_l$</td>
<td>2.77</td>
</tr>
<tr>
<td>Mean Process</td>
<td>$\mu_u$</td>
<td>0.664</td>
</tr>
<tr>
<td>Positive operating cost</td>
<td>$\hat{c}_f$</td>
<td>9.5</td>
</tr>
<tr>
<td>Distribution Op. Costs</td>
<td>${\xi(\hat{c}_f), \xi(\infty)}$</td>
<td>{.100, .042}</td>
</tr>
</tbody>
</table>

The skilled labor share $\varepsilon_f$ is set to 0.286 to match the percentage of skilled workers a fraction of the population, $\gamma_f + \varepsilon_f$ is set to 0.64 a standard value, and the capital share is based on previous estimates of the degree of decreasing returns to scale at the firm level as in Restuccia and Roger-son (2008). In particular, in the formal sector, we set $\alpha + \varepsilon_f + \gamma_f = 0.85$, and in the informal sector we set $\alpha + \gamma_i = 0.85$. The risk free interest rate $r$ is set to 4% per year to match the average real return on a 5 year T-bill over the last 30 years. We assume that $\beta = 1/1 + r$. The depreciation rate $\delta_k$ is set to 7%, and the depreciation rate of skilled labor will be set to $\delta_s = 0.015$ to match the average yearly return to college education reported by Psacharopoulos and Patrinos (2004). We normalize the unskilled wage rate to 1, and calculate the skilled labor wage rate through equation (5) given 6 years of schooling. The duration of education is set to 6 to match the average years of schooling in US as in Barro and Lee (1999). The value of the entry cost $c_e$ is calibrated as in Hopenhayn and
Rogerson (1993), we find the value of $c_e$ that, in equilibrium, satisfies the free entry condition with equality. We assume that the operating fixed cost can take values of $\{0, \hat{c}_f, +\infty\}$. The parameters $\{\tau, c_\tau, \tau_\omega, \kappa, \lambda, \phi\}$ are taken directly from the values reported in the World Bank Doing Business database (2009) for the U.S. economy. We set the tax rates $\tau = 0.23$, $c_\tau = 0.09$ and $\tau_\omega = 0.20$; the entry cost $\kappa = 0.26$; and the bankruptcy parameters to $\lambda = 0.77$ and $\phi = 0.07$.

We are left with 5 more parameters to calibrate: the mean of the productivity process of the large scale and small scale projects $\mu_l$ and $\mu_u$ respectively, the operating cost $c_f$, and the associated probabilities $\xi(\hat{c}_f)$ and $\xi(\infty)$. To obtain values for these parameters, we target the size of the informal labor force, measured as those workers not covered by a pension scheme (as reported by World Development Indicators 2006), the average size of formal establishments in the U.S. and the exit rates distribution across the size of firms, the percentage of the skilled labor to labor force and the capital-labor ratio. The data regarding the size distribution of establishments (in the formal sector) and exit rates in the US comes from the Statistics of US Business (SUBS) data set for the years 2003-2004. It is the same data used in Moscoso Boedo and Mukoyama (2008). Table (2) shows the data moments and the corresponding model moments. The average size of a formal establishment is 17.6 % in the US data, in our model this figure is 14.08. The size of the informal

Table 2: Target Moments

<table>
<thead>
<tr>
<th>Moment</th>
<th>Us Data</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Formal Est.</td>
<td>17.6</td>
<td>14.08</td>
</tr>
<tr>
<td>Informal Sector (fraction of Labor Force)</td>
<td>7.8 %</td>
<td>8.28%</td>
</tr>
<tr>
<td>Skilled labor (fraction of the Labor Force)</td>
<td>30.03 %</td>
<td>32.68%</td>
</tr>
<tr>
<td>Exit Rate Distribution by Employment Size</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>1-4</td>
<td>14.88</td>
<td>12.56</td>
</tr>
<tr>
<td>5-9</td>
<td>6.72</td>
<td>7.81</td>
</tr>
<tr>
<td>10-19</td>
<td>5.57</td>
<td>4.64</td>
</tr>
<tr>
<td>20-49</td>
<td>4.91</td>
<td>4.20</td>
</tr>
<tr>
<td>50-99</td>
<td>4.58</td>
<td>4.20</td>
</tr>
<tr>
<td>100-249</td>
<td>4.16</td>
<td>4.20</td>
</tr>
<tr>
<td>250-499</td>
<td>3.9</td>
<td>4.20</td>
</tr>
<tr>
<td>500-</td>
<td>4.22</td>
<td>4.20</td>
</tr>
</tbody>
</table>
sector is 7.8% in the data, and in our model it is 8.28%.

After calibrating the model using our target moments, we test our calibration using the distribution of US formal establishments by size (Table 3). The model does a good job generating the right distributions of operating establishments in the formal sector by size. Regarding size, it generates the right number of small establishments (with less than 19 employees), but misses at the very low end of the distribution (less than 5 employees).

<table>
<thead>
<tr>
<th>Total Size Distribution</th>
<th>Data %</th>
<th>Model %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-4</td>
<td>48.6</td>
<td>32.68</td>
</tr>
<tr>
<td>5-9</td>
<td>21.8</td>
<td>26.44</td>
</tr>
<tr>
<td>10-19</td>
<td>14.2</td>
<td>20.58</td>
</tr>
<tr>
<td>20-49</td>
<td>9.6</td>
<td>14.88</td>
</tr>
<tr>
<td>50-99</td>
<td>3.2</td>
<td>3.95</td>
</tr>
<tr>
<td>100-249</td>
<td>1.8</td>
<td>1.41</td>
</tr>
<tr>
<td>250+</td>
<td>0.7</td>
<td>0.04</td>
</tr>
</tbody>
</table>

By construction the exit and the entry rates are the same in the model, which is found to be 7.8%. The entry and exit rates in the data are 11.1% and 10.2% respectively. Thus, compared to the US data, the model average entry and exit rates are three and two percentage points lower respectively.

6 The Effects of Country Specific Institutions

In this paper we analyze whether the institutional frictions explain the differences in TFP, and ask if these TFP differences lead to differences in the skill distribution across countries. Since the model is computationally intensive we limit our analysis to 4 country income groups, high income countries (HIC), upper middle income countries (UMIC), lower middle income countries (LMIC) and low income countries (LIC).8 We use the Doing Business 2009 data set to obtain the

8Roughly, countries are classified as HIC if their GNI per capita is higher than 25% of the US, UMIC if their GNI per capita falls between 8% and 25% of the US, LMIC if their GNI per capita falls between 2% and 8% of the US and LIC if their GNI per capita is below 2% of the US.
median \((\lambda, \phi, \tau, c_\tau, \tau_\omega, \kappa)\) for each income group. Table (4) shows the parameter values for the US economy and for these income groups. We then compare the benchmark case (US) with the equilibrium across income groups. Our experiment can be described as follows. We first calibrate the model to the US economy by using \((\lambda, \phi, \tau, c_\tau, \tau_\omega, \kappa)_{US}\). In the benchmark case, we set \(\omega_n = 1\), and then iterate on the set of loan prices \(q_f^j(k', b', z)\) and \(q_i^j(k', b')\) until the lenders make zero profit on each contract and find the mass of entrants \(M\) that clears the labor market. Then for each income group, we set the group parameters to their values, and we iterate on the unskilled labor wage rate \(\omega\), and loan prices \(q_f^j(k', b', z)\) and \(q_i^j(k', b')\) until lenders make zero profits, and labor markets clear (given \(M\) obtained for US). Finally we adjust the creation cost for each income group \(c_e\) until the free entry condition is met.

### Table 4: Frictions Across Income Groups

<table>
<thead>
<tr>
<th></th>
<th>(\lambda)</th>
<th>(\phi)</th>
<th>(\tau)</th>
<th>(C_\tau)</th>
<th>(\kappa)</th>
<th>(\tau_\omega)</th>
</tr>
</thead>
<tbody>
<tr>
<td>US</td>
<td>0.77</td>
<td>0.07</td>
<td>0.23</td>
<td>0.09</td>
<td>0.20</td>
<td>0.20</td>
</tr>
<tr>
<td>High (HIC)</td>
<td>0.77</td>
<td>0.07</td>
<td>0.19</td>
<td>0.07</td>
<td>1.13</td>
<td>0.30</td>
</tr>
<tr>
<td>Upper Middle (UMIC)</td>
<td>0.30</td>
<td>0.15</td>
<td>0.15</td>
<td>0.15</td>
<td>1.86</td>
<td>0.39</td>
</tr>
<tr>
<td>Lower Middle (LMIC)</td>
<td>0.28</td>
<td>0.15</td>
<td>0.20</td>
<td>0.16</td>
<td>4.82</td>
<td>0.28</td>
</tr>
<tr>
<td>Low (LIC)</td>
<td>0.16</td>
<td>0.18</td>
<td>0.20</td>
<td>0.13</td>
<td>8.49</td>
<td>0.28</td>
</tr>
</tbody>
</table>

In order to understand the effects of country specific frictions on firms productivity, we compute total factor productivity using an aggregate production function both in the data and the model to compare it across equilibria associated with different frictions. In order to compute total factor productivity in the model and the data, we follow the cross country studies such as Klenow and Rodriguez-Clare (1997) or Hall and Jones (1999). They compute the following equation.

\[
TFP = \frac{Y}{K^\alpha H^{1-\alpha}}
\]

where \(Y\) denotes aggregate output, \(K\) denotes aggregate capital, \(H\) denotes some aggregate for labor (usually adjusted for human capital) and \(\alpha\) is the capital share. We follow the same procedure in our the model, where aggregate output is the sum across both formal and informal firms, aggregate capital is the sum of capital across establishments in both sectors and our aggregate
measure of labor equals one. We use the same parameter share as in Hall and Jones (1999), which equals 1/3. Table (5) displays the main results for each income group and compares the model to the data for the median country in the income group. Values of TFP and output per effective worker are taken from Hall and Jones (1999). The model TFP is calculated as in Hall and Jones (1999), by calculating the value of the human capital given the returns for every level of schooling. The informal labor force is reported by 2006 WDI as the share of labor force not covered by the pension scheme. Our model accounts for more than 2/3 of the TFP differences between US and

data. The informal labor force is reported by 2006 WDI as the share of labor force not covered by the pension scheme. The informal activity in our model ranges from around 8% in the US to 81% at the low end of the income distribution. The model output per effective worker values are up to four times higher than what is seen in the data, in the case of the Low Income Countries. The model does a decent job in terms of matching output per effective worker for the other country income groups.

In Table (6), we present other important moments across income groups to test our model in different dimensions. In terms of the average size distribution the model is on target both on average size as reported by Alfaro et al. (2009).

Our model predicts as frictions increase, the exit rate (and the entry rate, by construction) de-
Table 6: Differences across Income Groups

<table>
<thead>
<tr>
<th>Differences Across Income Groups</th>
<th>HIC</th>
<th>UMIC</th>
<th>LMIC</th>
<th>LIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avg Employment Formal</td>
<td>Data Model</td>
<td>Data Model</td>
<td>Data Model</td>
<td>Data Model</td>
</tr>
<tr>
<td>Capital per effective worker</td>
<td>1.05</td>
<td>0.95</td>
<td>0.38</td>
<td>0.56</td>
</tr>
<tr>
<td>Formal Entry Rate</td>
<td>0.81</td>
<td>0.75</td>
<td>0.65</td>
<td>0.59</td>
</tr>
<tr>
<td>Business Density</td>
<td>1.62</td>
<td>0.61</td>
<td>0.93</td>
<td>0.36</td>
</tr>
</tbody>
</table>

Note: Capital per effective worker, Formal Entry Rate, Business Density are reported relative to the US value. Data on average employment and variance of employment is taken from Alfaro et. al. (2009). Capital per effective worker is from author’s calculations based on Hall and Jones (1999). One unit of effective worker equals one unit of human capital. Data on the Formal Entry Rate and Business Density are taken from the 2008 World Bank Group Entrepreneurship Survey and Database. The model counterpart is obtained as total formal labor force over the average size of formal establishments which equals the measure of formal establishment to total population.

creases. This implies that for Low Income Countries countries operate the limited technology, firms stay in business for much longer, preventing the natural process of churning of unproductive firms. Also, the model generates a relative business density that is in line with the observed one (measured as the number of registered businesses as a percentage of the active population). The business density drops to 17% of the US’s for the Low Income Countries. High frictions generate low density, which generates low competitive pressures in the labor markets, generating low turnover in the formal sector (as observed by the low entry rate in developing economies), and lower average productivity.

7 Conclusion

The level of human capital has been considered as an important sign of development for a country. But there still remains an important gap between the human capital stocks of the developed and the developing world. In this paper, we built a firm dynamics model with imperfect capital markets, and measured institutional frictions to explain the cross country differences in stock of human capital and total factor productivity. In our model, entering and operating in the formal sector is costly, but allows firms to choose from an unrestricted set of technologies, while providing firms access to credit markets with better commitment (given by observed recovery rates and associated
costs), which leads to sorting into informal or the formal sector. We find that a low degree of
debt enforcement and high costs of formality leads to low allocative efficiency, a lower stock
of human capital and a larger informal sector characterized by low productivity firms. We find
that the using the measured frictions documented by the World Bank Doing Business database,
our the model explains more than two-thirds of the productivity differences between the US and
developing economies and is consistent with the cross country skill distribution. Consistent with
the data, we find a negative correlation between income per-worker, stock of human capital and a
sizable informal sectors that are comparable to the data.

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