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ABSTRACT

Human Capital and the Size Distribution of Firms*

Countries that have relatively fewer workers with a secondary education have smaller firms. The shortage of skilled workers limits the growth of more productive firms. Two factors influence the availability of skilled workers: i) the education level of the workforce and ii) large public sectors that predominantly hire individuals with a better education. We set up a model economy with a government and private firm formation where production requires unskilled and skilled jobs. Workers with a secondary education are pivotal as they can perform both types of jobs. We find that level of education and public sector employment account for 40-45% of the differences between the United States and Mexico in terms of average firm size, GDP per capita, and GDP per hour worked. We also show that the impact of public employment on skill premiums and productivity measures depends on the skill bias in public hiring.

JEL Classification: J24, J45, E24, H30, O11

Keywords: firm size, educational attainment, skill complementarities, public employment, college premium, high school premium

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1 Introduction

The size and productivity of firms differ widely across countries. In developing countries, the business landscape is characterized by small, informal, less productive firms, and few large firms. Across Europe, small firms are more frequent in southern countries. Differences in firm size and productivity have direct implications for aggregate total factor productivity and output, so understanding the causes of these differences is essential when designing growth policies.[1]

Literature on firm size distribution highlights several causes. Cabral and Mata [2003] and Erosa [2001] argue that financial frictions restrain the growth of firms. Hsieh and Klenow [2009] consider how distortions affecting marginal products of labor and capital lead to a departure from an efficient firm size distribution. Other explanations rely on policy aspects (e.g., Guner *et al.* [2008]), institutions (e.g., Grobovšec [2013]), or technology (e.g., Poschke [2011]). Antunes and Cavalcanti [2007] and Amaral and Quintin [2006] highlight the role of informality in Latin America. Empirical studies suggest that these explanations are all relevant, with limited access to credit, labor market regulations, corruption, and entry costs having a positive influence on informality, and a negative influence on firm size (see Loayza [1997], Chong and Gradstein [2007], or Johnson *et al.* [1998]).

We propose a novel mechanism to explain firm size differences across countries. We argue that a shortage of educated individuals makes it difficult for more productive firms to grow, leading to a landscape of small and unproductive firms. There are two main reasons for the shortage of skilled workers: i) a high percentage of the population does not have a secondary education, and ii) a large public sector that predominantly hires individuals with a higher level of education.

We first investigate the link between education and firm size using data from two leading surveys: the Enterprise survey and the Global Entrepreneurship Monitor survey. Controlling for GDP per capita, firm size is positively related to the percentage of workers with a secondary education rather than those with a college degree. This surprising result suggests that, in countries with few college graduates, workers with a secondary education take on skilled jobs.

[1] See IDB [2010] or Lora *et al.* [2001] for evidence on firm size distributions in Latin America, and Davis and Henrekson [1999] or Kumar *et al.* [2001] for firm size distributions in Europe. Braguinsky *et al.* [2011] find that the shrinking size of firms in Portugal is linked to the country's reduced aggregate productivity. Research by the IDB [2010] suggests that "in Latin America, reallocating resources could increase aggregate productivity by approximately 50–60 percent" (pg. 77).

Since the study by Lucas [1988], the idea that education is important to economic growth has received a lot of attention. Our model proposes one additional micro-channel, namely the combination of skilled and unskilled jobs in production, through which education affects productivity and, hence, growth. The literature on managerial layers has micro-founded skilled-unskilled job combinations, such as the studies by Rosen [1998], Garicano [2000], and Antras *et al.* [2008], which were further developed by Caliendo and Rossi-Hansberg [2012] and Bloom *et al.* [2012]. The latter present a model in which trust and a higher skill level of middle managers increase decentralization and firm size. We argue that fewer educated workers reduce the availability of middle managers, limiting firm growth.

We set up a model to quantify the effects of the educational composition of the labor force and of public employment on firm size and productivity. While we do not model a firm's managerial layers explicitly, we introduce the concept into a Lucas's [1978] span-of-control model. Agents in our model economy are endowed with managerial ability, as well as an education level (primary, secondary, or tertiary). According to their managerial ability, agents decide whether to become entrepreneurs or employees. Production requires capital, unskilled labor, and skilled labor, aggregated in a CES production function, similar to Krusell *et al.* [2000]. Workers with a primary education only carry out unskilled jobs. Workers with a tertiary education perform skilled jobs. Workers with a secondary education are pivotal, as they can not only carry out unskilled jobs better than workers with a primary education but also perform skilled jobs, albeit not as well as college graduates.

We follow the approach of existing literature and use Latin America as a case study, comparing the United States and Mexico. We first measure how differences in educational endowments and public employment in the two countries affect average firm size and productivity. Our mechanism explains about 40–45% of the differences in average firm size, GDP per capita, and GDP per hour worked between the two countries. The GDP per capita difference between the two countries is twice as large compared to a model with a single representative firm. The presence of a firm size distribution amplifies the effect of differences in education across countries. Using educational attainment data for over 100 countries, our model is able to replicate the relationship in our empirical study between firm size and educational attainment and, in particular, the stronger relationship with secondary education.

Our study is also related to prior research on the effect of public employment on private sector outcomes. It follows Hamermesh [1996] (chapter 10), who argues how public employment

biased towards more educated individuals can hinder economic development. While several studies consider the effects of public employment with homogeneous workers (e.g., Finn [1998] in an RBC model or Gomes [2014a] in a search and matching model), only few focus on the distinct effects across skill levels. In particular, Domeij and Ljungqvist [2006] find that the expansion of the Swedish public sector, that hired more low-skilled workers, can explain the difference in the evolution of the skill premium between the United States and Sweden.

The public sector is the largest employer in the economy, both in advanced and developing economies. Behar and Mok [2013] report that, on average for 194 countries, public sector employment accounts for 15% of total employment. Besides hiring a large fraction of the labor force, there is a bias towards skilled workers, equally common in both advanced and developing economies. Giordano *et al.* [2011] report that the average share of workers with a tertiary education is 2.6 times higher in the public than in the private sector in Euro Area countries, ranging from 1.6 times higher in Belgium to 4.3 times higher in Portugal. In the case of Latin America, Mizala *et al.* [2010] report that the average years of education in the public sector are 3 to 6 years higher than in the private sector, while Panizza [2000] finds the public sector to hire on average 30% of workers with at least secondary education. Assaad [1998] describes an even larger skill bias in Egypt, where the government hired 70% of females and more than 40% of males with a high school diploma or a university degree.

We show in our model that the effect of public employment on firm size and productivity varies with the skill of those hired by the public sector. Additionally, the negative effects of the public sector hiring skilled workers on productivity are much stronger in Mexico than in the United States. Without judging the benefits of hiring highly qualified public workers, this skill bias may have stronger repercussions in developing countries, where educated workers are scarce.

The remainder of this paper is organized as follows. Section 2 presents the empirical evidence on the relationship between the educational level of a country's workforce and the average firm size. Section 3 describes the model and Section 4 the calibration strategy. Then, Section 5 presents and discusses the results and policy experiments, after which Section 6 concludes the paper.

2 Firm size distribution and educational attainment

We investigate the relationship between education and firm size using data from the Enterprise Survey from the World Bank. The Enterprise Survey has gathered data on 130,000 non-agricultural firms in 135 emerging markets and developing economies since 2002. Note that firms with fewer than five employees are not surveyed.

Using the full micro data sample, we run a regression of the log of the firm size on age, sector dummies, time dummies, and country dummies. We then regress the estimated country dummies on educational attainment. We consider two measures of educational attainment: completed secondary education and some college, and completed tertiary education. According to Poschke [2011], there is a strong relationship between the average firm size in a country and its income per capita. We therefore control for the log of GDP per capita and the log of the population size. Data on the population and GDP per capita comes from the Penn World Tables and data on educational attainment from the Barro-Lee dataset. As a robustness check, we use data from the Global Entrepreneurship Monitor survey, which was

Table 2.1: Average employment per firm and educational attainment

	Enterprise survey			**GEM survey**		
	(1)	(2)	(3)	(1)	(2)	(3)
Income per capita	-0.016	0.101**	-0.007	0.303**	0.454***	0.296**
	(-0.33)	(2.04)	(-0.24)	(3.22)	(3.22)	(2.10)
Population	0.089***	0.089***	0.085***	-0.056	-0.050	-0.059
	(3.10)	(2.85)	(2.89)	(-1.16)	(-0.96)	(-1.20)
Secondary education	1.202***			1.217**		
	(2.80)			(2.17)		
Tertiary education		0.109			-0.091	
		(0.11)			(-0.07)	
Secondary plus			0.853***			0.837*
tertiary education			(3.15)			(1.75)
Observations	97	97	97	44	44	44
R-squared	0.251	0.135	0.218	0.413	0.344	0.391

*Notes: Data on educational attainment of the population over the age of 25 is taken from the Barro-Lee dataset for 2005. Tertiary education refers to the fraction of the population that has a college degree. Secondary education refers to the fraction of the population that has completed high school but does not hold a college degree. Data on population and income per capita is taken from the Penn World Tables. For the Enterprise survey, we run a regression of the log of the firm size on the firm's age, sector dummies, year dummies, and country dummies. The data in the sample refers to the period 2002 to 2012. We then regress the country dummies on the log of the population size, the log of the income per capita, and the level of education. For the Global Entrepreneurship Monitor survey, we use the log of the country's average firm employment, as calculated by Poschke [2011]. The t-statistics are shown in brackets.*** indicates significance at the 1% level, ** indicates significance at 5% level, and * indicates significance at the 1% level.*

conducted in more than 50 countries. In this dataset, we cannot control for sector or age of the firm, so we use data on the average firm size, as calculated by Poschke [2011] for the period 2001–2005. The results are shown in Table 2.1.

Perhaps surprisingly, the average firm size is positively related with the fraction of the population who completed their secondary education, but not with the fraction of college graduates. The coefficient of secondary education is statistically significant, even when controlling for GDP per capita, and has a similar magnitude in both surveys. This suggests that for average firm size, what matters most is the pool of workers with an intermediate level of education (i.e., completed secondary education or some college). While in advanced economies, workers with an intermediate education perform unskilled jobs, in developing countries, they already take on skilled jobs. This flexibility makes them pivotal and more important in determining firm size than the number of college graduates.

3 Model

We build a model economy à la Lucas [1978], comprising a single representative household and a government. The household is made up of a continuum of members with different managerial abilities. According to their managerial abilities, household members become either employees or entrepreneurs. There are three types of employees in the economy: a fraction, p, of individuals has primary education, a fraction, s, has completed secondary education, and a fraction, t, has completed tertiary education, with $p+s+t=1$. Entrepreneurs produce a homogeneous good by using unskilled labor, skilled labor, capital, and their ability as inputs. A household decides on levels of consumption and savings given the joint income of the household members.

Household The household is composed of a continuum of members. Its total size is normalized to unity. The household maximizes the infinite sum of discounted utilities given by

$$\sum_{t=0}^{\infty} \beta^t log(C_t), \tag{3.1}$$

where C_t denotes total household consumption at time t and $\beta \in (0,1)$ is the discount factor. Since we focus on the steady state and for expositional clarity, we omit the time subscript, t, from the description of the model.

Endowments Each household member has one unit of productive time that he/she supplies inelastically. Household members differ in their level of education and managerial abilities, z_i, distributed in $Z = [0, \overline{z}]$, with cdf $F(z_i)$ and density $f(z_i)$. The household assigns occupations to its members depending on their abilities and education. They can become either workers or entrepreneurs.

Production Each entrepreneur, i, has access to the same technology, rents capital, and hires different types of workers. Workers with a primary education are hired as unskilled workers, $n_{p,i}$. Workers with a university degree are hired as skilled labor, $h_{t,i}$. Finally, workers with a high school diploma can be hired for unskilled work, $n_{s,i}$, or for skilled work, $h_{s,i}$. Firms produce a single good according to the following CES production function

$$y_i = y(n_{p,i}, n_{s,i}, h_{s,i}, h_{t,i}, k_i) = z_i^{(1-\gamma)}[\mu(X_i^n)^\sigma + (1-\mu)[\lambda k_i^\rho + (1-\lambda)(X_i^h)^\rho]^{\frac{\sigma}{\rho}}]^{\frac{\gamma}{\sigma}}, \tag{3.2}$$

where ρ and σ govern the elasticities of substitution between inputs. The production function differs from *Krusell et al.* [2000] in two aspects. First, $\gamma \in (0,1)$ is the span-of-control parameter. The scale of production is increasing in the enhanced span-of-control (i.e., the entrepreneur's ability, z_i). Second, the unskilled and skilled labor inputs, X_i^n and X_i^h, respectively, are aggregations of workers with different education levels, given by:

$$X_i^n = ((\epsilon^n n_{p,i})^\psi + (n_{s,i})^\psi)^{\frac{1}{\psi}} \tag{3.3}$$

$$X_i^h = ((\epsilon^h h_{s,i})^\psi + (h_{t,i})^\psi)^{\frac{1}{\psi}}, \tag{3.4}$$

where $1/(1-\psi)$ is the elasticity of substitution between workers with different education levels. If $\psi = 1$, then these workers are perfect substitutes. The parameter ϵ^n indicates the productivity discount of workers with primary education relative to those with a high school degree when carrying out unskilled jobs. Similarly, ϵ^h reflects the productivity discount of workers with a high school degree relative to university graduates performing skilled tasks.

Entrepreneurs Entrepreneurs choose the number of workers, their skill composition, and capital to maximize their firm's profits. Given the production function, they always choose a strictly positive amount of all inputs. Given the wages per education level (w^p, w^s, w^t) and

a rental rate for capital (r^k) the entrepreneurs' problem is given by

$$\max_{\{n_{p,i},n_{s,i},h_{s,i},h_{t,i},k_i\}} \Pi_i = y_i - w^p n_{p,i} - w^s n_{s,i} - w^s h_{s,i} - w^t h_{t,i} - rk_i. \tag{3.5}$$

The first-order conditions are:

$$f'_{n_p} = w^p \tag{3.6}$$

$$f'_{n_s} = f'_{h_s} = w^s \tag{3.7}$$

$$f'_{h_t} = w^t \tag{3.8}$$

$$f'_k = r. \tag{3.9}$$

The entrepreneur equates the marginal productivity of each factor to its cost. Combining the first-order conditions for labor, we can show that:

$$\frac{h_{s,i}}{h_{t,i}} = \left(\frac{w^t(\epsilon^h)^\psi}{w^s}\right)^{\frac{1}{1-\psi}}, \tag{3.10}$$

$$\frac{n_{p,i}}{n_{s,i}} = \left(\frac{w^s(\epsilon^n)^\psi}{w^p}\right)^{\frac{1}{1-\psi}}. \tag{3.11}$$

Firms hire more workers with a high school degree for skilled positions if their productivity discount is small, and if the college premium is high. For unskilled positions, the firm hires more workers with secondary education if the productivity discount of workers with only primary education is high and if the high school premium is low.

The Household's problem The household chooses a level of consumption and savings, and the optimal occupation for each household member, $\{C, K', z^*, z^{**}, z^{***}\}$, in order to maximize Equation 3.1 subject to

$$\begin{aligned} C + K' \;=\; & rK(1-\tau) + (1-\delta)K + (1-\tau)[pw^p F(z^*) + sw^s F(z^{**}) + tw^t F(z^{***}) + \\ & + t\int_{z^{***}}^{\overline{z}} \pi(z_i,.)f(z)dz + s\int_{z^{**}}^{\overline{z}} \pi(z_i,)f(z)dz + p\int_{z^*}^{\overline{z}} \pi(z_i,.)f(z)dz], \end{aligned}$$

where π represents a firm's before-tax profits. The household income includes the capital income, the wage income, and the profits of its members who are entrepreneurs. All income is taxed at rate τ, which is used to finance the government's wage bill. The solution to the household's problem is characterized by the following first-order conditions, evaluated at the

steady state:

$$r = \frac{1}{(1-\tau)}(\frac{1}{\beta} - 1 + \delta), \tag{3.12}$$

$$w^p = \pi(z^*, .), \tag{3.13}$$

$$w^s = \pi(z^{**}, .). \tag{3.14}$$

$$w^t = \pi(z^{***}, .). \tag{3.15}$$

Condition (3.12) is the standard Euler equation for optimal capital accumulation, which determines the equilibrium interest rate. Conditions (3.13)–(3.15) are similar to Lucas' [1978] condition for the "marginal' entrepreneur. Wage payments have to equal the profits individuals expect to make as entrepreneurs. Household members with a primary, secondary, and tertiary education, and managerial abilities z^*, z^{**} and z^{***}, respectively, are indifferent between working or setting up a firm.

Government The government in this economy hires workers of all three education levels to produce the government consumption good. It collects taxes on wages, profits, and capital income. The tax rate is determined to balance the budget, given by

$$[\varphi^t l^g w^t + \varphi^s l^g w^s + \varphi^p l^g w^p] = \tau[rK + w_p F(z^*)p + w_s F(z^{**})s + w_t F(z^{***})t + p\int_{z^\star}^{\overline{z}} \pi(z_i, .)f(z)dz + s\int_{z^{\star\star}}^{\overline{z}} \pi(z_i, ;)f(z)dz + t\int_{z^{\star\star\star}}^{\overline{z}} \pi(z_i, ;)f(z)dz]. \tag{3.16}$$

The government chooses the level of public sector employment, l^g, and the composition of workers, φ^p, φ^s, and φ^t, with $\varphi^p + \varphi^s + \varphi^t = 1$. Wages paid by the government are equal to those paid in the private sector, a common assumption in models with frictionless labor markets.[2]

Equilibrium In equilibrium, all five markets must clear: the three labor markets plus the capital and goods markets. Denote the demand for primary, secondary, tertiary labor services, and capital by an entrepreneur with ability z_i by $n_{p,i}(z_i, w^p, w^s, w^t, r)$, $n_{s,i}(z_i, w^p, w^s, w^t, r)$, $h_{s,i}(z_i, w^p, w^s, w^t, r)$, $h_{t,i}(z_i, w^p, w^s, w^t, r)$, and $k_i(z_i, w^p, w^s, w^t, r)$, respectively. For the labor

[2]Empirical evidence indicates that wages in the public sector are higher than in the private sector, particularly for low-educated workers; see Gregory and Borland [1999]. In our model, given that the government always hires an exogenous number of workers, a higher public sector wage would only affect the government's wage bill but not its ability to hire. See Gomes [2014b] for a discussion of the effects of different public sector wage premiums in a model with search and matching frictions.

market to clear:

$$\begin{aligned} P \equiv F(z^*)p &= \varphi^p l^g + p\int_{z^*}^{\overline{z}} n_{p,i}(z_i, w^p, w^s, w^t, r) f(z)dz + s\int_{z^{**}}^{\overline{z}} n_{p,i}(z_i, w^p, w^s, w^t, r) f(z)dz \\ &\quad + t\int_{z^{***}}^{\overline{z}} n_{p,i}(z_i, w^p, w^s, w^t, r) f(z)dz. \end{aligned} \tag{3.17}$$

The aggregate supply of workers with primary education, P, must equal the sum of labor demands by all entrepreneurs and the government. For workers with a secondary and tertiary education, the labor market clears when:

$$\begin{aligned} S \equiv F(z^*)s &= \varphi^s l^g + p\int_{z^*}^{\overline{z}} n_{s,i}(z_i, w^p, w^s, w^t, r) f(z)dz + p\int_{z^*}^{\overline{z}} h_{s,i}(z_i, w^p, w^s, w^t, r) f(z)dz \\ &\quad + s\int_{z^{**}}^{\overline{z}} n_{s,i}(z_i, w^p, w^s, w^t, r) f(z)dz + s\int_{z^{**}}^{\overline{z}} h_{s,i}(z_i, w^p, w^s, w^t, r) f(z)dz + \\ &\quad t\int_{z^{***}}^{\overline{z}} n_{s,i}(z_i, w^p, w^s, w^t, r) f(z)dz + t\int_{z^{***}}^{\overline{z}} h_{s,i}(z_i, w^p, w^s, w^t, r) f(z)dz \end{aligned} \tag{3.18}$$

and

$$\begin{aligned} T \equiv F(z^{***})t &= \varphi^t l^g + p\int_{z^*}^{\overline{z}} h_{t,i}(z_i, w^p, w^s, w^t, r) f(z)dz + s\int_{z^{**}}^{\overline{z}} h_{t,i}(z_i, w^p, w^s, w^t, r) f(z)dz \\ &\quad + t\int_{z^{***}}^{\overline{z}} h_{t,i}(z_i, w^p, w^s, w^t, r) f(z)dz. \end{aligned} \tag{3.19}$$

The market clearing condition for capital is given by:

$$\begin{aligned} K &= p\int_{z^*}^{\overline{z}} k_i(z_i, w^p, w^s, w^t, r) f(z)dz + s\int_{z^{**}}^{\overline{z}} k_i(z_i, w^p, w^s, w^t, r) f(z)dz \\ &\quad + t\int_{z^{***}}^{\overline{z}} k_i(z_i, w^p, w^s, w^t, r) f(z)dz. \end{aligned} \tag{3.20}$$

With $y_i(z_i, w^p, w^s, w^t, r)$ being the supply of goods by any entrepreneur of ability z_i, for market clearing in the goods market, we require

$$\begin{aligned} p\int_{z^*}^{\overline{z}} y_i(z_i, w^p, w^s, w^t, r) f(z)dz + s\int_{z^{**}}^{\overline{z}} y_i(z_i, w^p, w^s, w^t, r) f(z)dz \\ + t\int_{z^{***}}^{\overline{z}} y_i(z_i, w^p, w^s, w^t, r) f(z)dz = C + \delta K. \end{aligned} \tag{3.21}$$

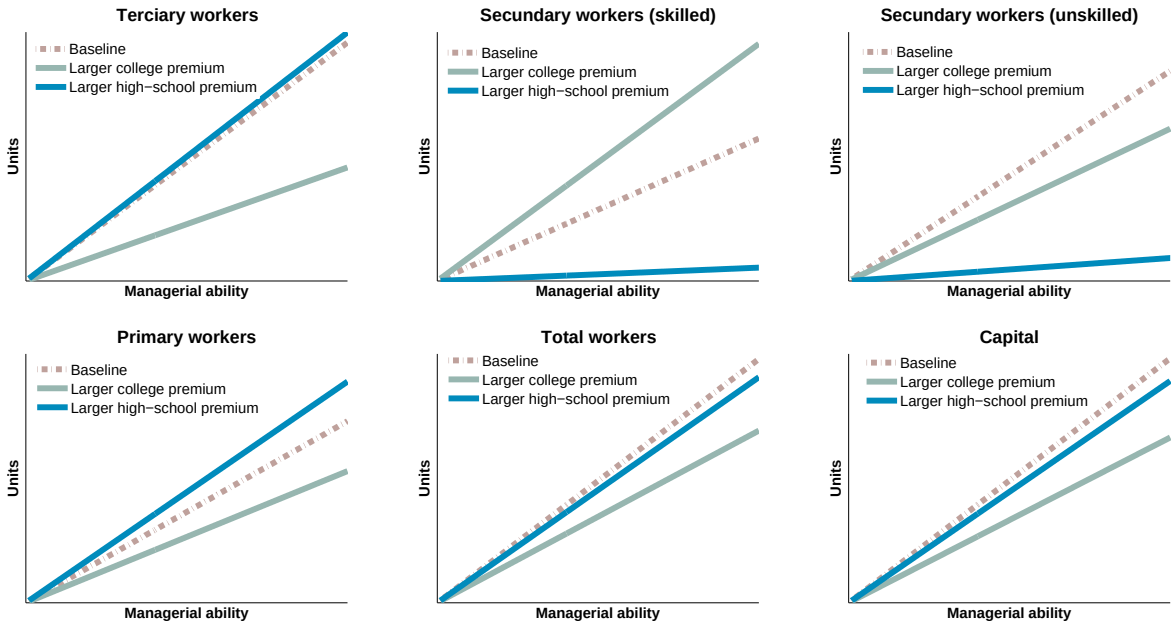
We can now define a competitive equilibrium for the model economy in the steady state.

Given a government policy $\{l^g, \varphi^p, \varphi^s, \varphi^g\}$ and a sequence of prices for labor and capital $\{w^p, w^s, w^t, r\}$, a competitive equilibrium is a collection of thresholds $\{z^*, z^{**}, z^{***}\}$, a tax rate $\{\tau\}$, and allocations $\{P, S, T, K', C\}$, such that:

1. $\{z^*, z^{**}, z^{***}\}$ solve the household's problem (i.e., equations (3.13)–(3.15) hold) ;
2. the rental rate is determined by the Euler equation (3.12);
3. the five markets for goods, capital, primary, secondary, and tertiary labor all clear (i.e., equations (3.17)–(3.21) hold);
4. the tax rate, τ, balances the government's budget (i.e., equation (3.16) holds).

In order to illustrate the main mechanism of the model, we show how potential entrepreneurs of any talent would adjust their input choices when faced with different factor prices. Figure 3.1 shows these adjustments when entrepreneurs face higher college or high school premiums. When tertiary wages are high (gray line), entrepreneurs substitute away from workers with a university degree and hire more workers with a secondary education to perform skilled jobs. The productivity of those workers in skilled positions is lower, and firms thus hire fewer unskilled workers and use less capital. Overall, for each level of entrepreneurial ability,

Figure 3.1: Sizes of firms, for different college and high school premiums



firms will be smaller. When the wages of workers with a secondary education are higher (dark line), firms substitute away from these workers towards college graduates to perform skilled jobs, and towards workers with a primary education for unskilled jobs. Workers with a primary education are less productive in unskilled positions; hence, firms use less capital and operate on a smaller scale.

4 Calibration

We fix some parameters based on available evidence, and estimate the remaining ones using the Simulated Method of Moments to match certain features of the US data. Table 4.2 displays the chosen parameter values. We fix the discount factor β to 0.96 and the depreciation rate, δ, to 8%, following Kydland and Prescott [1982]. According to the OECD [2011], in 2008, public employment made up 14.6% of the US labor force. Among US public employees, 50.7% hold a college degree, 46.4% have completed secondary education, and only 2.8% have not graduated from high school (Current Population Survey (CPS) for 2010). According to data from the Bureau of Labor Statistics in 2010, the educational composition of the US labor force above the age of 25 was as follows: 34.7%, 56.4%, and 9% had a tertiary, secondary, and primary education respectively. Hence, more than one-fifth, 21%, of tertiary educated labor is employed by the public sector.

The quantitative predictions of our model depend on the elasticities of substitution between the three inputs to production. We set the parameters governing those elasticities, ρ and σ, to -0.5 and 0.4, as estimated by Krusell *et al* [2000]. These numbers imply an elasticity of substitution between skilled and unskilled labor of 1.7, in the range of estimates surveyed in Hamermesh [1996].

The remaining parameters are estimated. Even though in a general equilibrium model all parameters affect all targets, we briefly discuss the data moments that each parameter is most likely to determine. The weight of capital in production, λ, is 0.6 to target the private capital-output ratio of 2, as established for the United States in Kamps [2006]. According to data from the Bureau of Labor Statistics, between 2000 and 2010, the average college premium was 63% and the high school premium was 40%. To match these numbers, the relative productivities of secondary to tertiary and primary to secondary workers are estimated to be 0.61 and 0.70, respectively. Between 2005 and the second quarter of 2007, the average wage compensation made up around 63% of GDP and corporate profits, together with proprietors'

Table 4.2: Baseline calibration

Parameters fixed	**Source**	**US**	**Mexico**
Discount factor (β)	Kydland and Prescott (1982)	0.960	-
Depreciation rate (δ)	Kydland and Prescott (1982)	0.080	-
Substitution between capital and skilled labor (ρ)	Krusell *el al.* (2000)	-0.495	-
Substitution between unskilled and skilled labor (σ)	Krusell *el al.* (2000)	0.401	-
Fraction of primary educated labor (p)	BLS and INEG	0.089	0.649
Fraction of secondary educated labor (s)	BLS and INEG	0.565	0.204
Fraction of tertiary educated labor (t)	BLS and INEG	0.346	0.146
Public employment (l^g)	OECD	0.146	0.100
- of those primary educated (ρ^p)	CPS and INEG	0.028	0.251
- of those secondary educated (ρ^s)	CPS and INEG	0.464	0.345
- of those tertiary educated (ρ^t)	CPS and INEG	0.507	0.405
Parameters estimated	**Target**		
Scale parameter (xm_z)	Mean establishment size	2.035	-
Shape parameter (a_z)	Establishment share (< 10)	0.750	-
Substitutability of secondary educated workers (ψ)	Establishment share (20-99)	0.976	-
Additional highest managerial ability (z_{max})	Establishment share (> 100)	1253.6	-
Mass of highest managerial ability (f_{max})	Employment share (> 100)	0.001	-
Span-of-Control (γ)	Profits share	0.859	-
Weight of Unskilled Labor in Production (μ)	Labor share	0.236	-
Weight of Capital in Production (λ)	Capital-output ratio	0.598	-
Productivity of secondary educated workers (ϵ_h)	College premium	0.609	-
Productivity of primary educated workers(ϵ_u)	High school premium	0.697	-

income, were 13.3% of GDP (Bureau of Economic Analysis). These targets determine the weight of unskilled labor in production, μ, of 0.24 and the span-of-control parameter, γ, of 0.86.

We take as the empirical counterpart of a unit of production, establishments rather than firms. We assume that managerial ability is distributed according to a (truncated) Pareto distribution, with shape parameter a_z and scale parameter xm_z. In order to be able to capture the mass of large establishments, we follow Guner *et al.* [2008] and impose the condition that this distribution only accounts for a mass of $(1 - f_{max})$ of establishments. To account for the remainder of the distribution of establishments, we choose an additional value for managerial ability, z_{max}, and its corresponding share, f_{max}. According to the Business Dynamic Statistics of the US Census, establishments with more than 100 employees make up 2.6% of all establishments (average for 2000–2010). These establishments account for 44.5% of employment. Small establishments, with fewer than 10 workers, make up 70.4% of all establishments. Around 12.8% of establishments have between 20 and 99 employees. The same dataset provides us with a mean establishment size of 17.5. The parameters, a_z,

Table 4.3: Calibration targets and model values

Targeted moments	**Source**	**Data**	**Model**
Mean establishment size	US Census	17.46	17.46
Establishment share, < 10 employees	US Census	0.704	0.700
Establishment share, 20-99 employees	US Census	0.128	0.104
Establishment share, > 100 employees	US Census	0.026	0.025
Employment share, > 100 employees	US Census	0.445	0.434
Capital-output-ratio	Kamps (2006)	2.000	1.997
Profits to GDP	BEA	0.133	0.127
Wage bill	BEA	0.630	0.603
College Premium	BLS	0.630	0.630
High School Premium	BLS	0.400	0.400
Not targeted moments	**Source**		
Employment share, < 10 employees	US Census	0.146	0.195
Employment share, 20-99 employees	US Census	0.297	0.232
Self-employment rate	OECD	0.071	0.046
Self-employment rate, adjusted	US Census	0.018	0.046

xm_z, z_{max}, f_{max}, and ψ are estimated to be 0.75, 2.03, 1253.6, 0.001, and 0.98, respectively. Note that ψ is close to unity, implying a high substitutability between workers with different levels of education performing the same type of job.

Our model matches the data well. Table 4.3 displays the calibration targets next to the model values, as well as some additional moments that were not targeted. The model somewhat underestimates the labor share of the economy, as well as the fraction of mid-size establishments.[3] On the other hand, the model somewhat overestimates the employment share of small establishments, while underestimating that of mid-size establishments. There are also fewer entrepreneurs in the model compared to the data. According to OECD statistics, 7.05% of the US labor force was self-employed in 2010, while in the model, only 4.63% of individuals set up a firm. This difference is partly because the model only considers firms with at least one employee. However, around 75% of businesses in the United States are non-employers (US census). Adjusting the self-employment rate for this number would result in a low 1.76% of the labor force owning a firm with employees, which is clearly smaller than the model's statistic. While each firm in the model has one entrepreneur, in the data, one entrepreneur is likely to own various firms.

To evaluate the impact of the supply of skilled labor, we compare our benchmark economy to an identical economy, but using the educational attainment and public employment policy of

[3]This seems to be a problem of the Pareto distribution, while the common alternative—the log-normal distribution—performs worse in the upper tail of the distribution. For more information, see Coad [2009].

Mexico. The data for Mexico come from the Encuesta Nacional de Ocupación y Empleo of the Instituto Nacional de Estadistica y Geografía (INEG), available for the 3rd and 4th quarter of 2010. Around 15% of the Mexican labor force held a college degree, 20% had completed their secondary education, and 65% had, at most, received an incomplete secondary education.[4] According to the OECD [2011], in 2008, Mexico's public sector (public administration or publicly owned firms) hired 10% of the labor force. Among public employees, more than 40% held a college degree, while only 25% had not completed secondary education. These numbers are shown in the last column of Table 4.2.

5 Results

5.1 United States versus Mexico

The level of education of the Mexican labor force is much lower than that of the US labor force. Even though Mexico has one of the smallest public sectors among OECD countries, public employment is clearly biased towards skilled individuals. More than one-fourth, 28%, of all employees with a tertiary education work in the public sector. The absorption of skilled labor by the public sector is thus more acute in Mexico than in the United States. What does this imply for the private sector and, in particular, for firm size and productivity?

Table 5.4 displays the benchmark results for the United States next to those for Mexico. For Mexico, we show the results for a case in which the tax rate adjusts to keep the budget balanced and another one where the government uses lump-sum taxes. In our model, the mean firm size in Mexico is lower than in the US, where the average Mexican firm has five fewer workers compared to the average US firm. Given the observed size of US (17.46) and Mexican firms (5.4 workers, see INEG [2014]), our model can explain around 41% of the difference.Firms in Mexico operate on a smaller scale and also use less capital. This leads to a low capital-output ratio of 1.65. McGrattan and Smith [1999] estimate the US capital-output ratio to be 1.32 times that of Mexico. In our model, the private capital-output ratio in the United States is 1.2 times that of Mexico, accounting for 63% of the relative difference.

Capital costs in our model are the same in the United States and Mexico (in column 3,

[4]The fraction of those with a tertiary education is similar to that in Machin and McNally [2007] for the population aged 25–64 in 2003, but higher than that in Barceinas [2005] for the population aged 15 and above in 2000.

Table 5.4: Results: United States and Mexico

	United States	**Mexico**	
Variables		*No tax adjustment*	*Tax adjusted*
Mean establishment size	17.46	12.45	12.45
Establishment share, < 10 employees	0.70	0.80	0.80
Establishment share, 20-99 employees	0.10	0.07	0.07
Establishment share, > 100 employees	0.03	0.02	0.02
Employment share, > 100 employees	0.43	0.44	0.44
Capital-output-ratio	2.00	1.66	1.64
Profits to GDP	0.13	0.12	0.12
Labor share	0.60	0.65	0.65
College premium	0.63	0.64	0.64
High school premium	0.40	2.71	2.68
Tax Rate	0.10	0.10	0.12
Productivity measures			
Entrepreneurs	0.05	0.07	0.07
Average managerial talent	100	71.85	71.84
Output per establishment	100	46.58	46.35
Employment by largest establishments	100	99.27	99.24
Private sector output per worker	100	65.31 (78.2)	65.02 (77.9)
Private sector output per capita	100	67.36 (82.3)	67.05 (82.1)
GDP per worker	100	70.12 (86.5)	69.78 (86.1)
GDP per capita	100	68.61 (86.5)	68.27 (86.1)

Notes: result of model simulations. In brackets are the results from a model with a representative firm with constant returns to scale ($\gamma = 1$), under the same calibration.

they only differ slightly due to higher taxes). It is the higher skill premiums in Mexico that drive the differences in firms' input choices. The skill premium for those with a tertiary, but especially secondary education is much higher in Mexico; more than six times the one in the United States. This is high, but it is qualitatively in line with empirical evidence. According to López-Acevedo [2001], workers with a college degree in Mexico earn 53% more than those with an upper secondary education, who in turn earn 70% more than those with a primary education and 170% more than those with no schooling. In contrast to the United States, in Mexico there is a larger relative difference in wages between those with a primary and secondary education than between those with a secondary and tertiary education.

Productivity in Mexico is lower when comparing all measures. In line with OECD data, more individuals in Mexico set up firms than in the United States. More entrepreneurs implies lower average managerial talent. More managers of lower talent who produce with less capital and on smaller scales leads to lower private output per worker. GDP—the sum of private output and the government's wage bill—is also lower. According to OECD statistics, GDP per capita (current PPP adjusted US$) in Mexico in 2010 was around 31% of that in

the United States. In our model, Mexican GDP per capita is equal to 69% of US GDP, accounting for around 45% of the observed difference. Similarly, our mechanism is able to capture around 46% of the difference in workers' productivity, measured as GDP per worker/per hours worked.

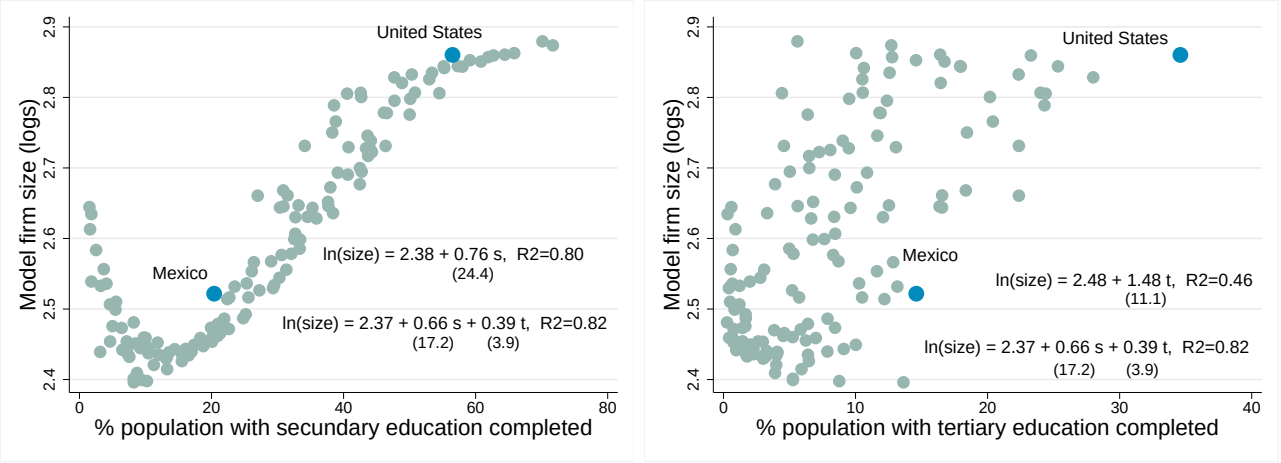
A model with a representative firm would also generate differences in GDP per capita, because of the lower educational attainment in Mexico. To quantify how much the distribution of firms can amplify these differences, we compute the productivity measures in a model with a representative firm and constant returns to scale in production. In the model with firm size distribution, the relative GDP per capita between the United States and Mexico is twice as high compared to the model with a representative firm.

5.2 Cross-country analysis

Using data on educational attainment for all countries from the Barro-Lee dataset, we test how well the model is able to replicate the positive cross-country relationship between educational attainment and average firm size. We assume that the government hires 21% of all college graduates and 12% of all high school graduates, the same fractions as in the United States. The hiring of workers with primary education is such that the overall level of public employment is 14.6%, as in the United States.

The first chart of Figure 5.2 shows the positive relationship between secondary educational attainment and average firm size. The slope of the regression is close to 0.76, compared

Figure 5.2: Mean firm size and educational attainment in model



Data: Educational Attainment: Barro-Lee dataset; Firm size: Model

to 1.2 found in Section 2, confirming that secondary education plays a crucial role for firm size. The R-squared is 0.80. Adding the fraction of those with a tertiary education to the regression of the log of the firm size on secondary education marginal raises the R-squared to 0.82, suggesting a limited contribution of tertiary education to firm size. The second chart confirms this, showing much more dispersion in the relationship between tertiary education and firm size.

5.3 Increase in public employment

We run a policy experiment that increases public employment in the United States and Mexico by five percentage points, financed by lump-sum taxes. We test three different scenarios for hiring additional workers: (i) only hiring those with a tertiary education, (ii) only hiring those with a secondary education, and (iii) only hiring those with a primary education. Table 5.5 displays the percentage variation in the model's moments compared to the respective benchmark for the United States and Mexico. Additional public employment offers an attractive outside option to setting up a firm. Fewer individuals become entrepreneurs. The average managerial talent increases and the labor share of the economy increases, while profits to GDP fall. Less private output is produced, and even as more production takes place within the public sector, GDP per capita and GDP per worker fall. Less employment is concentrated in the most productive firms. Lastly, smaller large firms and a larger public sector that does not use capital leads to a lower capital-output ratio.

The impacts of public sector hiring are more pronounced in Mexico relative to the United States, particularly when hiring more educated workers. While hiring college graduates raises the college premium by 1.7% and the high school premium by 1.1% in the United States, it raises the same statistics by 4% and 27% in Mexico. In addition, while the US private sector output per worker falls by 1.4%, that in Mexico falls by 11 percent. The increase in public employment causes firms to hire fewer skilled employees and to operate on a smaller scale. Given capital-skill complementarity, fewer skilled workers reduces the capital-output ratio.

A final important conclusion is that the effects of public sector hiring clearly depend on which type of worker is hired. For instance, in Mexico, if all additional public employees have a tertiary education, the private sector output per worker falls by 11% and profits by 13%. However, if the additional employees are high school graduates the effects are only 4% and 8%, respectively. These results do not differ when the increase in public sector hiring is

Table 5.5: Increase in public employment – % changes relative to respective benchmark (United States/Mexico)

	Tertiary only		**Secondary only**		**Primary only**	
Variables	US	Mexico	US	Mexico	US	Mexico
Mean establishment size	2.28	0.93	-1.03	-1.56	-1.91	-1.65
Establishment share, < 10 employees	-1.28	0.03	0.53	0.55	1.02	0.48
Establishment share, 20-99 employees	2.86	2.33	-1.40	-1.43	-2.58	-2.10
Establishment share, > 100 employees	5.28	4.27	1.40	1.06	0.35	3.23
Employment share, > 100 employees	0.79	2.78	-0.21	0.99	-0.58	0.26
Employment share, < 10 employees	-2.84	-4.98	1.32	-1.26	2.89	0.62
Capital-output ratio	-5.61	-16.78	-3.33	-9.79	-2.34	-9.70
Profits to GDP	-5.35	-13.16	-3.22	-7.57	-2.33	-8.86
Labor share	3.64	8.30	2.17	4.82	1.53	5.04
College premium	1.68	4.10	-0.80	-2.21	-0.53	0.61
High school premium	1.11	27.19	0.73	16.41	-9.79	4.14
Productivity measures						
Entrepreneurs	-7.87	-6.36	-4.93	-4.17	-4.12	-9.28
Average managerial Talent	6.65	4.26	4.07	2.85	3.42	7.77
Output per establishment	0.89	-9.76	0.69	-5.33	1.11	-1.74
Employment by largest establishments	-4.09	-3.19	-4.90	-4.29	-5.16	-8.74
Private sector output per worker	-1.36	-10.59	1.74	-3.83	3.08	-0.09
Private sector output per capita	-7.05	-15.50	-4.27	-9.28	-3.06	-10.86
GDP per worker	-2.14	-3.14	-1.33	-2.14	-0.94	-2.84
GDP per capita	-1.77	-2.70	-1.09	-1.85	-0.75	-2.19

financed by an increase in income taxes, as shown in Table A.1 of the Appendix.

6 Conclusion

Many alternative mechanisms have been proposed to explain why the business landscape in developing countries is characterized by small and less productive firms and few large firms. We find that, empirically, the educational attainment of a country's population is positively related to firm size, particularly in the case of the fraction of the population who has completed secondary education. Our mechanism combines this finding with another established fact, namely that public sector employment tends to absorb a large proportion of skilled individuals.

In our model economy with a government and private firm formation, production requires unskilled and skilled jobs. Secondary educated workers are pivotal, as they can perform both types of jobs. A shortage of educated individuals increases wage premiums and reduces the hiring of skilled and unskilled workers, as well as the use of capital in production. This leads

to smaller and less productive firms. Calibrated to the United States, our model can account for around 40–45% of the differences in average firm size, GDP per capita, and GDP per hour worked between the United States and Mexico.

Empirical findings have suggested an important role of secondary education in reducing income inequality (see Tilak [1989]). Our model proposes a possible micro mechanism of how a larger fraction of those with a secondary education can lead to higher output, lower wage premiums, and thus a lower wage inequality. Regarding public policies, we show how these may unintentionally affect firm size and productivity. In particular, effects may be different depending on which skill groups are hired by the public sector. Our model thus allows us to measure the effects of public sector hiring that go beyond those already pointed out by previous studies, such as queuing or changes in skill premiums.

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A Appendix

Table A.1: Tax-financed increase in public employment - % changes relative to respective Benchmark (US/Mexico)

	Tertiary only		**Secondary only**		**Primary only**	
Variables	US	Mexico	US	Mexico	US	Mexico
Mean establishment size	1.94	2.22	-1.40	-1.69	-2.53	-0.43
Establishment share, <10 employees	-1.13	-0.35	0.67	0.60	1.29	0.06
Establishment share, 20-99 employees	2.34	3.75	-1.91	-1.75	-3.37	-0.81
Establishment share, >100 employees	4.87	5.60	0.99	0.88	-0.38	4.54
Employment share, >100 employees	0.69	2.60	-0.31	0.77	-0.71	0.18
Employment share, <10 employees	-2.54	-4.98	1.62	-0.73	3.28	0.27
Capital-output-ratio	-9.37	-24.11	-5.66	-14.41	-4.04	-15.20
Profits to GDP	-5.26	-12.56	-3.17	-7.29	-2.29	-8.57
Labor share	3.05	6.99	1.81	4.06	1.28	4.16
College Premium	1.60	4.10	-0.86	-2.21	-0.58	0.61
High School Premium	0.79	20.27	0.54	12.66	-9.88	0.11
Tax rate	0.15	0.23	0.13	0.18	0.12	0.19
Productivity measures						
Entrepreneurs	-7.58	-7.46	-4.61	-4.05	-3.52	-10.32
Average managerial talent	6.38	5.47	3.80	2.82	2.90	8.94
Output per establishment	-1.22	-11.62	-0.73	-7.19	-0.27	-2.84
Employment by largest establishments	-4.17	-3.08	-5.00	-4.39	-5.27	-8.60
Private sector output per worker	-3.10	-13.54	0.68	-5.59	2.32	-2.42
Private sector output per capita	-8.70	-18.22	-5.30	-10.95	-3.78	-12.86
GDP per worker	-3.97	-6.97	-2.41	-4.23	-1.71	-5.39
GDP per capita	-3.62	-6.47	-2.19	-3.95	-1.54	-4.69