Human Capital and Financial Development: Firm-Level Interactions and Macroeconomic Implications*

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Abstract

Capital-skill complementarity in production implies non-trivial interactions between availability of human capital and financial constraints. Firms that are constrained in their access to finance hire a lower proportion of skilled workers than unconstrained firms. On the other hand, higher wages of skilled workers reduce firms' desired capital intensity and thus loosen their effective financial constraints. We build a dynamic occupational-choice model to quantify how a lack of human capital and financial frictions, as well as the joint effect of both restrictions interact to explain cross-country differences in aggregate output per capita, productivity, average firm size and college premia. We calibrate our model to US data, and we vary financial frictions and educational attainment as observed across countries. We find that the joint effect of both restrictions is up to 50 percent larger compared to the sum of the individual effects. In countries with a negligible share of tertiary educated workers, financial development has small effects on aggregate output.

JEL Classification: O11, O40, E22, J24, E24.

Keywords: financial liberalization, financial frictions, capital-skill complementarity, educational attainment, entrepreneurship, college premium.

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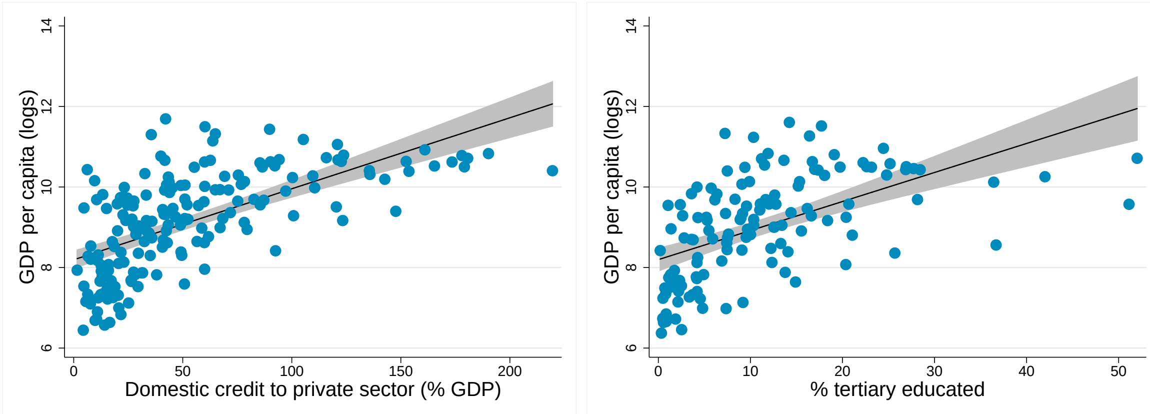
1 Introduction

Low levels of physical capital and its misallocation together with a lack of human capital are among the main causes behind income disparities across countries. While already emphasized in the classic Solow [1956] - Swan [1956] model, recent literature on the misallocation of capital has suggested different micro mechanisms. Underdeveloped financial markets in particular are found to have important effects for entrepreneurship and firm-level outcomes such as size and productivity, with resulting macroeconomic implications for aggregate income. These findings point to a positive relationship between domestic credit as a measure of financial market development and countries' Gross Domestic Product (GDP) per capita, as depicted in the left-hand graph of Figure 1. On the other hand, the importance of human capital for economic growth has been discussed in the literature since the classical works of Lucas [1988], Barro [1991] or Mankiw *et al.* [1992]. This idea is usually illustrated with a positive correlation between countries' GDP and educational attainment, shown in the right-hand graph of Figure 1.

However, how a lack of human capital and the presence of financial frictions impact countries' aggregate income has typically been analyzed separately. We argue that these two sources of economic development should be analyzed jointly, given the widely accepted view in macroeconomics that capital and skilled labor are complements in production (Griliches [1969]; Krusell et. al [2000]). We show that capital-skilled complementarity implies a non-trivial interaction between human capital and financial frictions at a firm-level with far-reaching macroeconomic implications. The gains from financial development depend crucially on countries' educational attainment, which can explain why some episodes of financial deepening were more successful (e.g. East Asian countries) than others (e.g. Latin American countries). On the other hand, gains from education reforms, depend on how developed financial markets are.

Taking capital-skill complementarity in production as given, we aim to quantify the importance of financial frictions, lack of human capital, and the joint effect of these restrictions for explaining cross-country differences in output per capita, productivity, college premia and average firm size. To this end, we build a dynamic occupational-choice model *à la* Lucas [1978] where individuals with different skill level and wealth decide to set up a firm or to work. As in Allub and Erosa [2019], individuals accumulate assets but can only borrow up to a certain fraction of their wealth. Production uses capital, skilled and unskilled labor as inputs. Under capital-skill complementary, firms that are constrained in their access to finance

Figure 1: Economic development, credit and human capital



Source: Domestic credit and GDP data from World Bank, World Development Indicators. Educational attainment of the population age 25 and above from Barro and Lee [2013], average over 1995-2005.

hire a lower proportion of skilled labor than unconstrained firms. Also, high skilled wages, reduce firms' desired capital intensity and hence loosen the effective financial constraint.

To discipline our model, we calibrate it to US data, following Buera and Shin [2013]. Our main exercise consists of varying financial frictions and educational attainment as observed across countries. This accounting exercise allows us to quantify how much of the differences in output, average firm size and productivity with respect to the US can be attributed to differences in: i) financial frictions ii) lack of human capital, and iii) the joint effect of both restrictions. We find that the joint effect is up to 50 percent larger compared to the sum of the individual effects. In countries with a negligible share of tertiary educated workers, financial development has small effects on aggregate output. Running cross-country regressions of GDP and TFP on the share of tertiary educated and the ratio of domestic credit to GDP, we confirm that the positive relationships in our model are also observed in the data. We also compare our model output to microdata from the World Bank Enterprise survey. We show that, controlling for several other characteristics, the fraction of skilled workers within a firm depends positively on the firm's level of assets, and that this relationship is stronger in countries with lower financial market development. Our estimated coefficients using firm level data are remarkably similar to those obtained when using model-generated data.

Highlighting the mechanisms behind our findings, we first show that to depart from a unique optimal ratio of skilled to unskilled labor for all firms and to generate dispersion in this ratio, one needs a combination of two elements: financial frictions and capital-skill complementarity. Either one of these conditions alone is not sufficient. Furthermore, there are two reasons why in our model human capital of the population plays a crucial role. First, as wages of unskilled workers are lower than wages of skilled workers, more unskilled individuals decide to set up a firm. In an environment with many unskilled individuals this reduces average firm size and productivity, similarly to Gomes and Kuehn [2017]. Second, human capital of the population, by affecting the desired capital intensity of firms, determines the degree to which financial constraints limit firm size. If there is a lack of human capital, firms' optimal level of physical capital is also lower. Hence, even as entrepreneurs see their access to finance improve, they might not increase their stock of physical capital by as much. Financial development in a context of low educational attainment will thus have very little effect on average firm size, productivity and output.

This result of our model may be useful for policy makers to evaluate under which circumstances financial market or educational reforms have a better chance of being successful. We consider the example of three countries: the Philippines, Mexico and Malawi, where 21, 11 and less than 1 percent of the population hold a college degree. Attaining financial market development as observed in the US would increase output by 24 percent in the Philippines, 21 percent in Mexico but only by 9.5 percent in Malawi. In our model financial frictions, a lack of human capital and the joint effect of both restrictions can explain up to 60 percent of the observed differences in GDP per capita between these three countries and the US.

Our mechanism focuses on the interaction of financial frictions and human capital via a firm's production function. This is a novel mechanism that differs from the more widely studied idea that capital market imperfections limit the accumulation of human capital and generate poverty traps. Recent work by Mestieri, Schauer and Townsend [2017] studies the effect of financial constraints on both, entrepreneurship and human capital accumulation of the next generation. The authors find that financial constraints hurt individuals in the center of the income and asset distribution, and that they lead to a higher correlation of household assets and children's schooling. The authors consider that workers with different levels of schooling are perfect substitutes, and thus there is no room for capital being more complementary to skilled compared to unskilled labor in production. While in our main accounting exercise we take the educational attainment of the population as given, in an extension we endogeneize educational attainment, and allow it to respond to changes in financial frictions.

Our study is closely related to four papers that study the interplay between financial frictions and a lack of human capital. Lopez and Olivella [2012] present a real business cycle model and analyze how shocks to financial frictions affect firms' optimal mix of skilled and unskilled labor. The paper by Larrain [2015] proposes a simple framework with only two types of firms to test empirically how financial liberalization has led to more wage inequality. Berniell [2015] sets up a model of informality, occupational choice and investments in human capital with credit frictions, but she does not perform any quantitative analysis. Finally, Fonseca and Van Doornik [2019] provide very strong empirical evidence supporting the main mechanism present in our model. The authors consider a bankruptcy reform in Brazil that led to an expansion of credit, finding that firms that were constrained before the reform, increased employment, particularly of skilled workers, relative to previously unconstrained firms.

While most literature has thus overlooked the interplay between financial frictions and human capital, separately each strand of literature is quite large. Buera *et al.* [2015] provide an excellent overview of the literature on financial frictions that tends to study how these frictions cause deviations from efficient firm size distributions (see e.g. Cabral and Mata [2003], Erosa [2001], Hsieh and Klenow [2009] or more recently Cavalcanti et al. [2019]). More closely related to our paper are Allub and Erosa [2019] who add own-account workers to a model of occupational choice. In their model, reducing financial frictions leads to fewer own-account workers, more employers and larger firms. Buera, Kaboski and Shin [2011] in an occupational choice model and Midrigan and Xu [2014] in a model of firm exit and entry *a la* Hopenhayn [1992], both analyze the presence of financial frictions in an economy with two sectors. In both studies, relaxing financial frictions increases the size of the more productive sector, leading to gains in aggregate output. We contribute to this literature by generalizing the production function to include skilled and unskilled labor as inputs and to feature capital-skill complementarity.[1]

Regarding the second strand of literature, among recent papers that study how human capital impacts economic development via its effects on firm size and productivity are Gennaioli *et al.* [2013], Erosa *et al.* [2010]), Roys and Seshadri [2014], Poschke [2018] and Gomes and Kuehn [2017]. We contribute to this literature with two insights. First, we show that the magnitude of the positive effects of human capital on economic development depend crucially on how developed countries' financial markets are. A similar increase of 20 percentage points in the fraction of tertiary educated workers, raises output by 29 percent when financial frictions are small compared to only 19 percent when access to finance is more severely restricted. Second, the level of financial frictions is an important determinant of the college

[1] Our paper also relates to the broader literature on firm size distributions that has proposed other explanations as to why average firm size and productivity differ so much across countries, e.g. policy aspects (e.g. Guner *et al.* [2008]) or informality (e.g. Antunes and Cavalcanti [2007]).

premium: financial liberalizations raise skilled wages more than unskilled wages.

The remainder of this paper is organized as follows: The next section presents our model, and in Section 3 we discuss the calibration of our model, and we carry out two exercises that highlight the model's mechanisms. Section 4 shows and discusses the effects of varying financial frictions and educational attainment for output, wage inequality, and average firm size. In Section 5 we present robustness checks to the model including an open economy version of our model, a version with a Cobb-Douglas production function, and a model where we endogenize individuals' choice of acquiring an education. Finally Section 6 concludes.

2 Model

We build a model economy *à la* Lucas [1978] with a continuum of infinitely lived agents who differ in their skill levels as workers, their entrepreneurial abilities, and their asset holdings. Given their labor and capital income, each period individuals decide about consumption and savings. Depending on their asset holdings, entrepreneurial abilities, and skills, individuals also choose whether to become entrepreneurs or workers. Under perfect capital markets, only skill levels and managerial abilities determine individuals' occupational choices. However, under imperfect capital markets, asset holdings also play a role for whether individuals decide to become workers or entrepreneurs. Entrepreneurs produce a homogeneous good by using unskilled labor, skilled labor, capital, and their own abilities as inputs. Since we focus on steady states and for clarity of exposition, we initially omit the time subscript, t, from the description of our model.

Endowments Each individual has one unit of productive time that he supplies inelastically. Individuals differ in their skill levels as workers e, where $e = s, u$ (skilled (s) or unskilled (u)) and in their managerial abilities, z_i, distributed in $Z = [0, \overline{z}]$, and with cdf $F(z_i)$ and density $f(z_i)$. Individuals hold assets a_i, which are distributed in $A = [0, \overline{a}]$, with cdf $H(a_i)$ and density $h(a_i)$. This last distribution is an endogenous object in our model, and it is the outcome of individuals' consumption-savings decisions.

Production Each entrepreneur, i, has access to the same technology. He hires unskilled workers n_i^u, skilled workers n_i^s, and he rents capital k_i. Firms produce a single good according to the following CES production function

$$y_i(n_i^u, n_i^s, k_i) = z_i^{(1-\gamma)}[\mu(n_i^u)^\sigma + (1-\mu)[\lambda(k_i)^\rho + (1-\lambda)(n_i^s)^\rho]^{\frac{\sigma}{\rho}}]^{\frac{\gamma}{\sigma}}, \tag{1}$$

where ρ and σ govern the elasticities of substitution between inputs, μ is the share of unskilled labor in production, and λ is the share of capital in the composite input.

Imperfect capital markets In this economy, enforcement problems of contracts limit the amount of borrowing. In particular, entrepreneurs are only able to borrow an amount equivalent to χ times their asset holdings. Parameter $\chi \in [1; \infty]$ thus represents the strength of legal institutions in the economy, with $\chi = 1$ indicating the absence of any financial markets and $\chi = \infty$ corresponding to an economy with perfect capital markets.

Entrepreneurs Entrepreneurs choose the number of skilled and unskilled workers, as well as the amount of capital to maximize their firms' profits subject to the production function and a borrowing constraint. Entrepreneurs always choose strictly positive amounts of all inputs. Given wages per skill level (w^u, w^s) and a rental rate for capital (r), the entrepreneur's problem is given by

$$\max_{\{n_i^u, n_i^s, k_i\}} \pi(z_i, a_i) = y_i - w^u n_i^u - w^s n_i^s - r k_i, \tag{2}$$

subject to the technology (Equation 1) and the following borrowing constraint: $k_i < \chi a_i$. The first-order conditions of the entrepreneur's problem are:

$$\frac{\partial y_i}{\partial n_i^s} = w^s \quad , \quad \frac{\partial y_i}{\partial n_i^u} = w^u \quad , \quad \frac{\partial y_i}{\partial k_i} = r_i. \tag{3}$$

where $r_i = r + \Lambda_i$ and Λ_i is the multiplier on the collateral constraint. In Appendix A.1 we show how combining the first-order conditions, we can derive an expression for the entrepreneur's optimal ratio of skilled to unskilled labor given by:

$$\frac{n_i^s}{n_i^u} = \left[\frac{w^u}{w^s} \frac{(1-\lambda)(1-\mu)[\lambda(\frac{\lambda w^s}{(1-\lambda) r_i})^{\frac{\rho}{1-\rho}} + (1-\lambda)]^{\frac{\sigma-\rho}{\rho}}}{\mu} \right]^{1/(1-\sigma)}. \tag{4}$$

Notice that the optimal skill mix depends on r_i, which is firm-specific and depends on how closely binding the collateral constraint is. If firms are unconstrained in their access to finance, then $r_i = r$ and the right-hand-side of the expression only depends on aggregate prices and parameters. For all unconstrained firms the skilled-unskilled labor ratio is thus constant. For firms that are constrained in their access to finance on the other hand, the skill mix depends on the size of the multiplier and, in turn, on firms characteristics.

The role of capital-skill complementarity Calculating the derivative of the ratio of skilled to unskilled labor with respect to the cost of capital r_i we obtain the following expression

$$sign\left(\frac{\partial(\frac{n_i^s}{n_i^u})}{\partial r_i}\right) = sign\left(\frac{\rho-\sigma}{(1-\rho)(1-\sigma)}\right), \tag{5}$$

where both σ and ρ are smaller than 1. In particular, the sign is negative for the case of capital-skill complementarity in production $\rho < \sigma$. Entrepreneurs who are more financially constrained and hence face higher costs of capital will hire a lower ratio of skilled to unskilled workers. Notice that if $\sigma = \rho$, which includes the case of a Cobb-Douglas production function, entrepreneurs always employ the same ratio of skilled to unskilled labor, independently of their cost of capital.

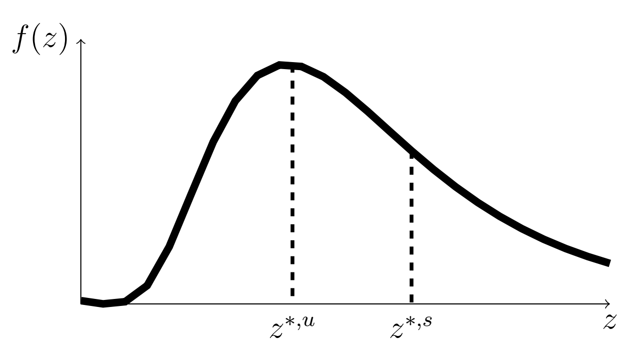
The individual's problem Individuals maximize the infinite sum of discounted utilities:

$$\sum_{t=0}^{\infty} \beta^t \frac{(c_t^i)^{1-\psi}}{1-\psi}, \tag{6}$$

where c_t^i denotes consumption of individual i at time t, and $\beta \in (0,1)$ is the discount factor. The parameter ψ determines individuals' degree of risk aversion. The individual chooses consumption and savings, and the optimal occupation, in order to maximize Equation 6 subject to the individual's budget constraint:

$$\begin{aligned} c_i + a_i' &= I_{z_i(a_i)<z^{*,e}(a_i)}(w^e + Ra_i) + \\ &+ I_{z_i(a_i)\geq z^{*,e}(a_i)}(\pi(z_i,a_i) + R * max(0,(a_i-k_i))). \end{aligned}$$

Figure 2: Thresholds for becoming an entrepreneur, by skill levels



We denote by $z^{*,e}(a_i)$ the marginal entrepreneur of skill e with asset holdings a_i. The individual's income includes wage and capital income if the individual chooses to become a worker, and it includes profits for those who choose to become entrepreneurs. The gross rental rate of capital in equilibrium is denoted by $r = R + \delta$. If entrepreneurs find it optimal to not use all their assets as capital in production, they earn an additional capital income. The solution to the individual's problem is characterized by the following condition determining the thresholds for becoming an entrepreneur for individuals of each skill level:

$$w^e + Ra_i = \pi(z^{*,e}(a_i), a_i) + R * max(0, (a_i - k_i)). \tag{7}$$

This condition is somewhat similar to Lucas' [1978] condition for the "marginal" entrepreneur. Wage payments plus capital income have to equal the profits individuals of a certain skill and with a certain amount of assets expect to make as entrepreneurs. Different wages for skilled and unskilled individuals translate into different thresholds, as depicted in Figure 2. However, note that once entrepreneurial abilities are drawn and certain individuals choose to become entrepreneurs, their returns are no longer dependent on their skill levels.

Value function for workers For an individual of skill e, managerial ability z_i and endowed with assets a_i, the value of being a worker is given by

$$V_e^{wk}(z_i, a_i) = \max_{\{a_i', c_i\}} \Bigg(U(c_i) + \beta\zeta E[I_{z_i(a_i')<z^{*,e}(a_i')} V_e^{wk}(z_i, a_i') + I_{z_i(a_i')\geq z^{*,e}(a_i')} V_e^{ent}(z_i, a_i')]$$
$$+\beta(1-\zeta)E[I_{z_i'(a_i')<z^{*,e}(a_i')} V_e^{wk}(z_i', a_i') + I_{z_i'(a_i')\geq z^{*,e}(a_i')} V_e^{ent}(z_i', a_i')] \Bigg),$$

where ζ is the probability that the individual keeps the same entrepreneurial ability z. With probability $1-\zeta$ individuals obtain new draws for their entrepreneurial ability. Furthermore, individuals who are workers today may, as they accumulate assets, decide to become entrepreneurs in the future.

Value function for entrepreneurs The value of being an entrepreneur for an individual of skill e, managerial ability z_i and endowed with assets a_i is given by

$$V_e^{ent}(z_i, a_i) = \max_{\{a_i', c_i\}} \Bigg(U(c_i) + \beta\zeta E[V_e^{ent}(z_i, a_i')]$$
$$+\beta(1-\zeta)E[I_{z_i'(a_i')<z^{*,e}(a_i')} V_e^{wk}(z_i', a_i') + I_{z_i'(a_i')\geq z^{*,e}(a_i')} V_e^{ent}(z_i', a_i')] \Bigg).$$

Notice that individuals who are entrepreneurs today can only become workers in the future if they draw a new managerial ability z, which happens with probability $1-\zeta$.

Equilibrium In equilibrium, all four markets must clear: the two labor markets plus the capital and goods markets. Denote the demand for skilled and unskilled labor services, and capital by an entrepreneur of managerial ability z_i by $n_i^s(z_i, w^u, w^s, r_i)$, $n_i^u(z_i, w^u, w^s, r_i)$, and $k_i(z_i, w^u, w^s, r_i)$, respectively. We assume that a fraction θ of the population is skilled. For the skilled labor market to clear, the supply of skilled workers has to equal the sum of demands for skilled labor by all entrepreneurs:

$$\begin{aligned}\theta \int_0^{\overline{a}} F(z^{*,s}(a_i))h(a)da &= \theta \int_0^{\overline{a}} \int_{z^{*,s}(a_i)}^{\overline{z}} n_i^s(z_i, w^u, w^s, r_i) f(z) dz h(a) da \\ &+ (1-\theta) \int_0^{\overline{a}} \int_{z^{*,u}(a_i)}^{\overline{z}} n_i^s(z_i, w^u, w^s, r_i) f(z) dz h(a) da.\end{aligned}$$

Similarly, the labor market for unskilled workers clears when:

$$\begin{aligned}(1-\theta) \int_0^{\overline{a}} F(z^{*,u}(a_i))h(a)da &= \theta \int_0^{\overline{a}} \int_{z^{*,s}(a_i)}^{\overline{z}} n_i^u(z_i, w^u, w^s, r_i) f(z) dz h(a) da \\ &+ (1-\theta) \int_0^{\overline{a}} \int_{z^{*,u}(a_i)}^{\overline{z}} n_i^u(z_i, w^u, w^s, r_i) f(z) dz h(a) da.\end{aligned}$$

The market clearing condition for capital is given by:

$$\begin{aligned}K \equiv \int_0^{\overline{a}} a_i h(a) da &= \theta \int_0^{\overline{a}} \int_{z^{*,s}(a_i)}^{\overline{z}} k_i(z_i, w^u, w^s, r_i) f(z) dz h(a) da \\ &+ (1-\theta) \int_0^{\overline{a}} \int_{z^{*,u}(a_i)}^{\overline{z}} k_i(z_i, w^u, w^s, r_i) f(z) dz h(a) da.\end{aligned}$$

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

$$\begin{aligned}C + \delta K &= \int_0^{\overline{a}} \int_{z^{*,s}(a_i)}^{\overline{z}} y_i(z_i, w^u, w^s, r_i) f(z) dz h(a) da \\ &+ \int_0^{\overline{a}} \int_{z^{*,u}(a_i)}^{\overline{z}} y_i(z_i, w^u, w^s, r_i) f(z) dz h(a) da.\end{aligned}$$

3 Calibration

We calibrate our model to data from the United States. Some parameters are set exogenously based on outside information or as normalizations, while the remaining parameters are calibrated to match US statistics for 2000-2010. Table 1 displays our chosen parameter values. We take several parameters from Buera and Shin [2013]. In particular, we fix the depreciation rate at 6 percent per year, we set the risk aversion parameter to 1.5, and we choose a probability of drawing a new managerial ability in each period of 0.106. The fraction of skilled individuals is set to 0.31, equal to the share of the US population above 25 with completed tertiary education according to Barro and Lee [2013]. As it is common in the literature, the United States is considered to have perfect capital markets, and hence χ the parameter governing the tightness of financial frictions is set to infinity. For the parameters governing the elasticities of substitution between capital, skilled and unskilled labor ρ and σ, we use values of -0.495 and 0.401 respectively as estimated by Krusell et al [2000].

Table 1: Baseline calibration

Parameters set exogenously	**Value**	**Source**
Depreciation rate (δ)	0.060	Buera and Shin [2013]
Risk aversion (ψ)	1.5	Buera and Shin [2013]
Prob. of drawing a new ability (ζ)	0.106	Buera and Shin [2013]
Fraction of skilled individuals (θ)	0.31	Barro and Lee [2013]
Tightness of financial frictions (χ)	∞	normalization
Production function		
Substitutability		
Capital and skilled labor (σ)	0.401	Krusell et al. [2000]
Capital and unskilled labor (ρ)	-0.495	Krusell et al. [2000]
Calibrated parameters	**Value**	**Target**
Span-of-Control (γ)	0.87	Profits to GDP ratio
Discount factor (β)	0.929	Real interest rate
Production function		
Weights		
Unskilled labor in production (μ)	0.439	College premium
Capital in Production (λ)	0.619	Capital-output ratio
Distribution of ability		
Shape parameter (α)	1.047	Mean establishment size
Scale parameter (ξ)	0.426	Relative size establishment unskilled-skilled manager

We are left with six parameters that are calibrated to match six targets. The parameter γ that determines decreasing returns at the firm level is set to 0.87 to match a ratio of profits to GDP of 0.13. As in Buera and Shin [2013], the value for the discount factor β targets an annual real interest rate of 4.5 percent. Turning to the parameters of the production function, the weight of capital in production, λ, is set to 0.64 to target a private capital-output ratio of 2, as established for the United States by Kamps [2006]. According to Goldin and Katz [2009], the college premium in the 2000 US Census was 61%. To match this number, μ is calibrated to a value of 0.439. Finally, we consider a Pareto distribution for managerial ability which can be characterized by two parameters α and ξ. Both skilled and unskilled individuals are assumed to draw their managerial abilities from the same distribution.[2] The parameters of this distribution are chosen to target two statistics on average firm size. According to the Business Dynamic Statistics of the US Census, mean establishment size was 17.5. The shape parameter α is set to 1.047 to match this number. The Survey of Business Owners (SBO 2007) has information about firm size and the education of managers. We restrict our sample to firms with managers who are majority owners. The average size of establishments with primary and secondary educated entrepreneurs was equal to 70% of the mean establishment. We set scale parameter ξ to 0.426 to target this number.

Table 2: Calibration targets and model values, baseline model

Targeted moments	**Source**	**Data**	**Model**
Profits to GDP ratio	BEA	0.13	0.13
Real interest rate	Buera and Shin [2013]	0.045	0.045
Mean establishment size	US Census	17.46	17.49
Relative size establishment skilled manager	SBO(2007)	0.70	0.70
Capital-output-ratio	Kamps [2006]	2.00	2.00
College Premium 2000	Goldin and Katz [2009]	0.63	0.63
Non-targeted moments	**Source**	**Data**	**Model**
Establishment share, < 10 employees	US Census	0.70	0.54
Establishment share, $10 - 19$ employees	US Census	0.14	0.23
Establishment share, $20 - 99$ employees	US Census	0.13	0.23
Establishment share, > 100 employees	US Census	0.03	0.01
Employment share, < 10 employees	US Census	0.15	0.20
Employment share, $10 - 19$ employees	US Census	0.10	0.16
Employment share, $20 - 99$ employees	US Census	0.30	0.39
Employment share, > 100 employees	US Census	0.45	0.24
Domestic credit to GDP ratio	WDI (2000)	1.62	1.56
Labor share	BEA	0.63	0.66
Self-employment rate	OECD	0.07	0.05

Table 2 displays our calibration targets next to the model's statistics, as well as some additional moments that were not targeted. Our model matches the data well, including several

[2] Gomes and Kuehn [2017] allow for skilled individuals to draw their managerial abilities from a different distribution than unskilled individuals, but once calibrated these distributions turn out to be similar. To keep our mechanism more transparent we prefer that all individuals draw their managerial ability from the same distribution, although we acknowledge that effects of education reforms might be larger if they also improve the distribution of managerial ability.

non-targeted moments. The model matches several statistics from the Business Dynamic Statistics of the US Census, regarding establishment and employment shares by firm size. The dimension with the worst performance is the employment share of large firms which is only 24 percent in the model, compared to 45 percent in the data.[3] Regarding aggregate statistics, the model slightly underestimates the ratio of domestic credit to GDP and generates a labor share that is slightly higher than in the data. In our model once we target average firm size, the self-employment rate is determined. In particular, targeting an average establishment size of 17.5 fixes the entrepreneurship rate in our model at 5% ($\frac{1-e}{e} = 17.5$; $e = 0.054$). The model thus underestimates the share of self-employed in the US population of 7% as reported by the OECD.[4]

3.1 Interaction between financial frictions and occupational choice

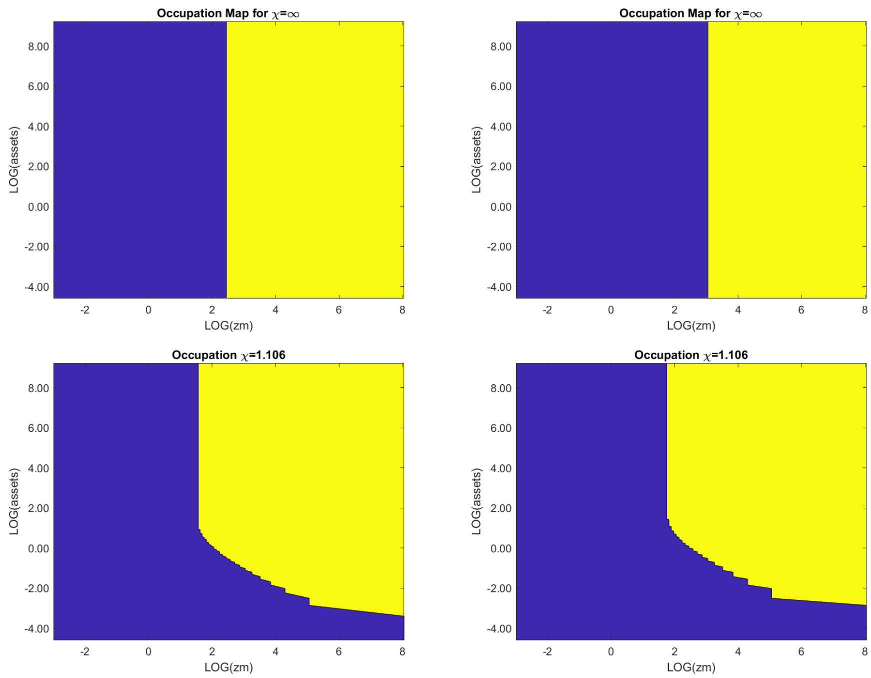
Given our calibration, we solve the model for economies with different shares of skilled individuals (θ) and different levels of financial frictions (χ). Figure 3 shows the occupational maps for the choice to become an entrepreneur (yellow) or a worker (blue) depending on individuals' assets and managerial abilities. To illustrate the interaction we consider an economy fully developed financial markets ($\chi = \infty$), shown in the top panels, and an economy with financial frictions ($\chi = 1.106$), shown in the bottom panels. On the left hand side, we show occupational maps for unskilled individuals while those for skilled individuals are displayed on the right hand side.

Without financial frictions the choice of becoming an entrepreneur or a worker only depends on individuals' managerial abilities and not on their assets. The vertical line separating the two occupations in both top panels indicates this. The line lies below the value of 3 for unskilled individuals but above the value of 3 for skilled individuals. Endowed with the same managerial ability, skilled and unskilled individuals would obtain the same profits as entrepreneurs but their outside options as workers are different. Unskilled individuals with relatively low managerial abilities choose to become entrepreneurs because alternatively they would obtain a lower wage as workers.

[3] A commonly used approach of fixing this issue is to add an extra tail to the distribution of managerial ability. However, given that our focus is not on replicating the US firm size distribution, and in order to keep the model simple, we abstain from doing so.

[4] The OECD statistic is also similar to the fraction of unincorporated self-employed over total employment in the US of 6-7% as reported in Hipple [2010]. As the author points out, many data sources tend to count incorporated self-employed as employees, potentially also our source for average establishment size. In this case the most comparable rate to our model statistic is the fraction of unincorporated self-employed.

Figure 3: Occupational maps for economies with and without financial friction



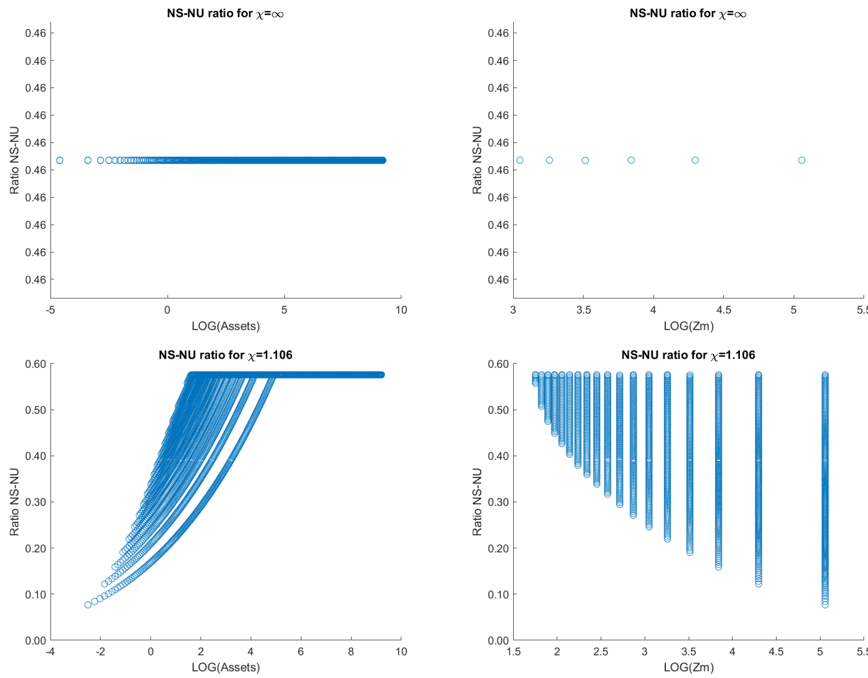
Notes: Entrepreneurs are colored yellow and workers blue. Top panels correspond to an economy without financial frictions ($\chi = \infty$) while bottom panels to an economy with financial frictions ($\chi = 1.106$). Left hand side shows occupational maps for unskilled individuals while for skilled individuals they are displayed on the right hand side.

With financial frictions on the other hand, occupational choices depend on individuals' assets. Even individuals with very high managerial abilities choose to become workers if they do not have any assets. On the other hand, in particular unskilled individuals with very low managerial abilities but large amounts of assets decide to become entrepreneurs.

3.2 Interaction between financial frictions and skill composition at the firm level

To highlight the interactions between financial frictions and capital-skill complementarity at the firm level, in Figure 4 we plot the skill composition of employment chosen by entrepreneurs depending on their assets and managerial abilities. The top panels show the skilled-to-unskilled labor ratio chosen by entrepreneurs in an economy without financial frictions ($\chi = \infty$), while the bottom panels show the same ratio for an economy with financial frictions ($\chi = 1.106$). In an environment with perfect capital markets, all entrepreneurs

Figure 4: Skilled-unskilled labor ratio at the firm level



Notes: Top panels correspond to an economy without financial frictions ($\chi = \infty$) while bottom panels to an economy with financial frictions ($\chi = 1.106$). Left hand side shows skilled-unskilled labor ratios for unskilled entrepreneurs while for skilled entrepreneurs they are displayed on the right hand side.

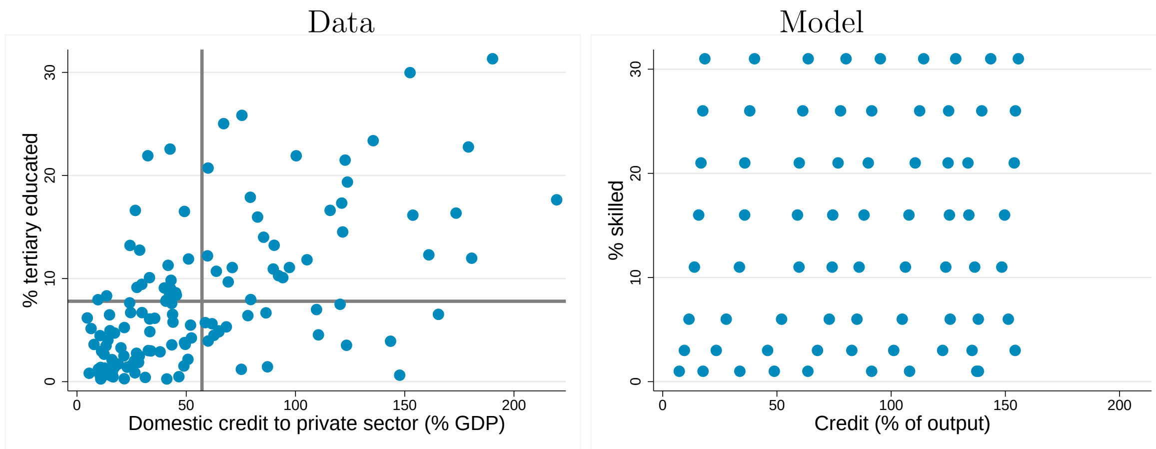
choose the exact same ratio of skilled to unskilled employment, independently of their assets or managerial abilities. With financial frictions on the other hand there is substantial dispersion in the skilled to unskilled labor ratio at the firm level which depends on entrepreneurs' assets and managerial abilities. The dispersion in the skilled-to-unskilled labor ratio can be interpreted as a measure of financial constraints. The more financially constrained entrepreneurs are, the lower their chosen capital stock relative to the optimal one. And as a consequence of capital-skill complementarity, more financially constrained entrepreneurs will also hire fewer skilled workers relative to unskilled workers.

4 Analysis

4.1 Effects of financial development and education on output

Our main exercise consist of varying financial frictions and educational attainment as observed in the data. The left hand graph of Figure 5 plots ratios of domestic credit to GDP

Figure 5: Domestic credit to GDP and educational attainment: data and model



Notes: For each country, data is averaged over 2004-2016. Sources: Domestic Credit to GDP from World Bank Development Indicators; Educational attainment from Barro and Lee [2013]. The right hand graph shows the grid for which the model was simulated. Top right grid point is the US benchmark.

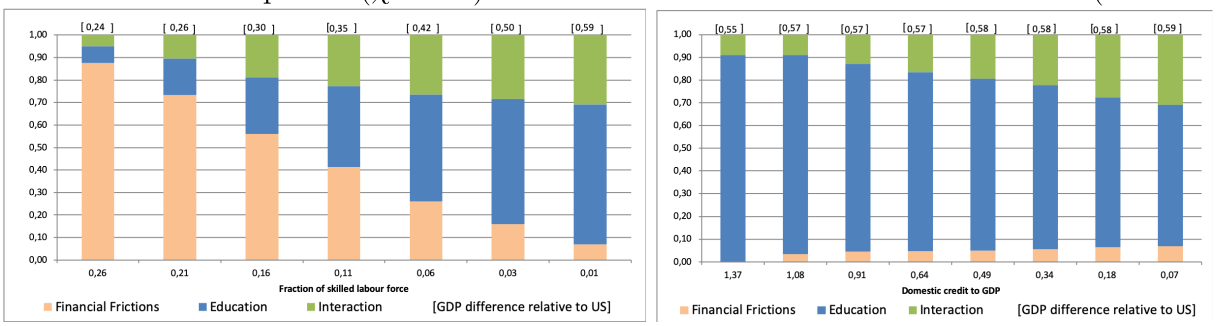
against the percentage of individuals with completed tertiary education across a range of 131 countries. We observe quite some variation in the data. Several countries are characterized by high educational attainment but low credit to GDP ratios, while others display high credit to GDP ratios but low educational attainment. We use these statistics to assign a realistic range to both χ and θ, as shown in the right hand graph. In Figure A.1 in Appendix A.1, we display the relative GDP per capita of these 131 countries with respect to US GDP, and compare them to the values generated within our model. On average, these two dimensions explain 50 to 60 percent of countries' observed GDP per capita gap relative to the US.

To provide a better understanding regarding the relative contribution of financial frictions, educational attainment and their interaction effect for differences in GDP, we conduct the following two exercises. First, for economies with a low level of financial development ($\chi = 1.1$) and different levels of educational attainment, we consider two reforms: full financial development ($\chi = \infty$) and an education reform that increases the supply of skilled labor to the US level ($\theta = 0.31$). We then consider a third scenario where both reforms are carried out simultaneously. The second exercise considers the same reforms carried out in economies with initially low levels of educational attainment ($\theta = 0.01$) and different levels of financial market development.

Figure 6 displays the results from these exercises and shows how each reform and their interactions contributes to the increase in output. For each scenario, the relative GDP per capita with respect to the US is shown in brackets above each column. The right hand graph

Figure 6: Effects of financial frictions and educational attainment on output

Low financial development ($\chi = 1.1$) Low educational attainment ($\theta = 0.01$)



Notes: Based on model simulations. The graphs plot the contribution of each factor (financial frictions, educational attainment and their interaction) to explain differences in GDP relative to the US. The left hand graph starts at $\chi = 1.1$ with different values of θ. The right hand graph starts at $\theta = 0.01$ with different values of χ. Numbers in brackets indicate GDP difference relative to the US. The last columns of the two graphs are equal.

corresponds to the second exercise. For very low levels of educational attainment, financial market reforms contribute very little to economic development. This is also reflected by the fact that financial market development alone increase relative GDP per capita by at most 8 percent. Considering the first exercise displayed in the left hand graph, we find that the importance of removing financial frictions depends crucially on a country's level of educational attainment. As seen before, the effect is negligible for very low levels, but when at least 15% of the population is skilled, improved access to finance becomes the main driver for economic development. Of particular interest are the interaction effects between the two reforms; for a close-up see Figure A.2 in Appendix A.1. When carried out jointly the effects on output are larger than the sum of the individual effects. In particular, in a scenario where initially financial frictions are high and educational attainment is low, the interaction effect amounts to almost 50 percent of the sum of the individual effects.

4.1.1 Three case studies

We now focus on three specific case studies: Mexico, the Philippines and Malawi. The Mexico-US comparison has sparked much interest in the literature. How much of the income differences can be explained by human capital and financial frictions? What would be the output gains for Mexico of increasing educational attainment and financial market development to US levels? In our model this requires increasing $\theta = 0.11$ to $\theta = 0.31$ and $\chi = 1.18$ (a domestic credit to GDP ratio of 24 percent) to $\chi = \infty$. We choose the other two countries for our case study because of their different levels of educational attainment. In the Philippines around 21 percent of the population has completed tertiary education while in Malawi this number is below 1 percent. Both countries have relatively low levels of domestic credit to GDP ratios of 32 and 11 percent respectively. For these two countries we also increase educational attainment and financial market development to the US level.

Table 3: Three case studies

	Mexico	**Philippines**	**Malawi**
Share of college educated	$\theta = 0.11$	$\theta = 0.21$	$\theta^s = 0.01$
Financial frictions	$\chi = 1.18$	$\chi = 1.21$	$\chi = 1.16$
Output model	0.478	0.544	0.299
Output with $\theta = 0.31$	0.571	0.575	0.569
Output with $\chi = \infty$	0.576	0.672	0.327
Gains from education reform	**19.3 %**	**5.7 %**	**90.3 %**
Gains from financial development	**20.5 %**	**23.5 %**	**9.5 %**
Sum of both reforms	**39.8 %**	**29.3 %**	**99.8 %**
Output model US	0.723	0.723	0.723
Both reforms jointly	**51.1 %**	**32.9 %**	**141.7 %**
Output relative to US data	**0.32**	**0.11**	**0.02**
Output relative to US model	**0.66**	**0.75**	**0.41**

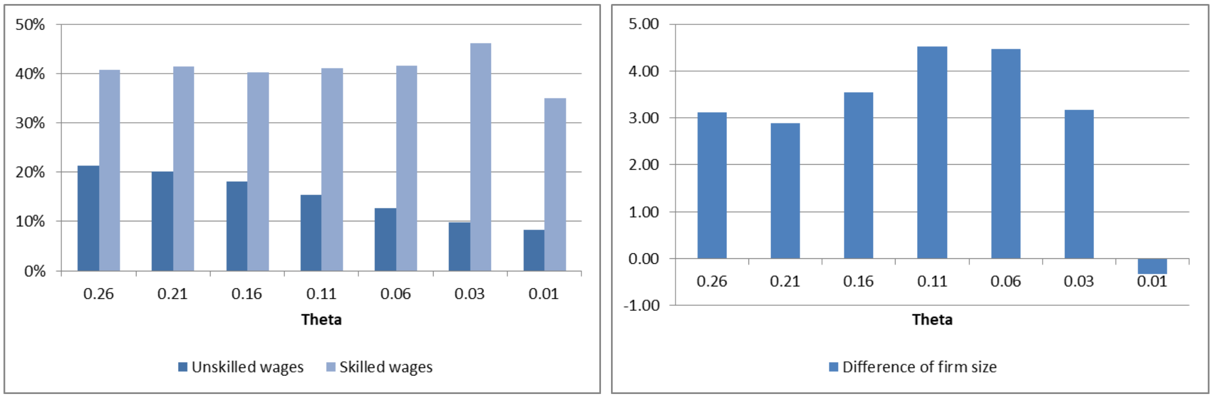
Table 3 displays the results for the three case studies. Differences in financial development and educational attainment in our model can capture approximately 50% of the difference in output between Mexico and the US. If Mexico's labor force were as skilled as the US labor force, but Mexico maintained its level of financial market development, output would increase by 19.3%. If on the other hand, Mexico had financial markets that were as developed as those in the US but kept its lower share of skilled individuals, output would increase by 20.5%. Finally, if simultaneously Mexico increased its share of skilled individuals and eliminated all frictions in financial markets, output would increase by 51%. The Philippines, with their relatively high share of college graduates would benefit the most from adopting a policy to achieve the US level of financial market development, increasing output by 23.5 percent. Education reforms in the Philippines however would only have modest effects, with an increase in output of 5.7%. Finally, Malawi is an interesting case. During the late 1980s and early 1990s the country implemented several reforms to liberalize financial markets, following the structural adjustment programs sponsored by the International Monetary Fund and the World Bank. These reforms do not seem to have spurred domestic credit, which is only 11 percent of GDP. Our model suggests that given the country's low educational attainment, financial deepening in Malawi has limited effects on output (an increase of less than 10 percent). This becomes especially evident when compared to the effects of reforms that increase the educational attainment of the population. Our results are in line with the conclusions in Kabango and Paloni [2010] and Chirwa [2001]. Both papers study the effects of financial market liberalizations in Malawi. The former find an increase in industrial concentration and a decrease in net firm entry, particularly in sectors that are more finance dependent, while the latter point to higher intermediation margins, higher credit to the public sector but lower credit to the private sector.

4.2 Effects of financial frictions on wage inequality and firm size

Capital-skill complementarity implies a clear link between the use of capital in production and wages of skilled workers. Hence, we expect financial market development that alters firms' capital intensities to have different effects for wages of skilled and unskilled workers, ultimately affecting wage inequality. The left hand graph of Figure 7 displays the percentage changes in skilled and unskilled wages as financial markets develop from an initially low $\chi = 1.1$ to $\chi = \infty$, for different levels of educational attainment. Financial market development increase both skilled and unskilled wages, but the effect is much larger for skilled wages, hence increasing wage inequality. In particular, the effect on skilled wages is between two to four times larger than the effect on unskilled wages. By how much wage inequality increases depends on a country's initial level of educational attainment. We observe stronger increases in wage inequality when financial market development is carried out in countries where very few individuals hold a college degree.

Removing financial frictions allows entrepreneurs to hire the optimal amount of capital and to thus grow to their optimal size. We hence expect financial market development to also affect average firm size. The right hand graph of Figure 7 shows the change in average firm size as financial markets develop from an initially low $\chi = 1.1$ to $\chi = \infty$, for different levels of educational attainment. Financial market development would, in general, increase average firm size. The only exception is a situation in which only 1 percent of the population has tertiary education. In this case there is an extreme shortage of human capital and skilled wages are very high. Few firms are profitable, and those that are will prefer to hire a large number of unskilled workers whose wages are very low. Hence, average firm size turns out to be slightly larger than in our US benchmark.

Figure 7: Effects of removing financial frictions on wage inequality and firm size



Notes: Based on model simulations. Both graphs consider a situation where financial markets develop from $\chi = 1.1$ to $\chi = \infty$ for different levels of educational attainment, θ. The left hand graph displays how skilled and unskilled wages change whereas the right hand graph shows how average firm size is affected.

4.3 Cross-country and firm-level regressions

In our model, increases in educational attainment and the removal of financial frictions lead to higher aggregate output. Running cross-country regressions, we first investigate if and how this relationship holds in the data. In particular, we regress the log of GDP per capita on the fraction of the population with tertiary education and on the ratio of domestic credit to GDP. These regressions produce the conditional slopes presented in Figure 1. We then reproduce the same regressions using model-generated data. Table 4 displays the unweighted regressions and Appendix A.1 shows the model regressions where each grid point is weighted by the number of countries whose data is closest. Results are similar. The positive relationships from our model hold in the data. Similar, as in Buera, Kaboski and Shin [2011], our model accounts for one third of the observed relationship between GDP and domestic credit. Regarding educational attainment and GDP, it accounts for two thirds of the relationship.[5]

We also run similar regressions for TFP, firm size, and college premia. Our model reproduces well the positive relationship between educational attainment and TFP, and it is able to capture 15 percent of the relationship between domestic credit and TFP. Furthermore

[5] Appendix A.1 shows regressions that include quadratic terms for both domestic credit and educational attainment, as well as an interaction term between the two. Coefficients on domestic credit and educational attainment in the data indicate a concave relationship with GDP per capita. However, in the model only the latter survives. The coefficient on the interaction term is positive and significant in both data and model regressions. However, with five estimated coefficients the comparison of the two regressions is more complicated, and hence we prefer to analyze linear specification.

Table 4: Cross-country regressions: model and data

	Data			**Model Closed Economy**	
	Domestic Credit to GDP	% of tertiary educated	Obs. (R^2)	Domestic Credit to GDP	% of tertiary educated
GDP per capita	0.339***	1.482***	131	0.106***	1.346***
(relative to US)	[0.18,0.49]	[0.41,2.55]	(0.33)	[0.078, 0.133]	[1.224,1.467]
TFP	0.269***	0.690*	67	0.037***	0.772***
(relative to US)	[0.16,0.37]	[-0.04,1.42]	(0.50)	[0.013, 0.061]	[0.666, 0.878]
Firm size	0.0051**	0.0155	97	0.0010***	-0.0014
(logs)	[0.001,0.010]	[-0.01,0.04]	(0.10)	[0.0004, 0.0015]	[-0.0037, 0.0009]
College premium	0.002**	-0.02**	97	0.001	-0.084***
(logs)	[0.000,0.005]	[-0.04,-0.003]	(0.08)	[-0.000, 0.003]	[-0.091, -0.076]

*Notes: The 95 confidence intervals are shown in brackets.*** significance at the 1% level, ** significance at 5% level, and * significance at the 10% level. For each country the data is the average for the period 2004-2016. Sources: GDP per capita PPP, Domestic Credit to GDP from World Bank Development Indicators; Educational attainment from Barro and Lee [2013] Data; TFP from Buera and Shin [2013]; Firm size in logs from Enterprise survey; College premium in logs takes from ILO (ratio of average wage in occupation Professionals over Plant and machine operators, and assemblers).*

our model also reproduces the positive relationship between average firm size and domestic credit, as well as the absence of a clear relationship between average firm size and educational attainment. Finally, our model does not capture the positive relationship between college premia and domestic credit, and it predicts a negative relationship between college premia and educational attainment that is stronger than the one observed in the data. The latter suggests that other elements that are absent from our model, namely skill-biased technological change, have raised returns to education.

Our model also generates predictions for the relationship between output, human capital, and access to finance at the firm level. To compare these predictions to those observed in the data, we turn to the World Bank's Enterprise Survey, and we regress the share of educated workers (with 10-12 years of education) on the log of firms' assets. We also control for country and industry fixed effects, and we include an interaction term between the log of assets and the domestic credit to GDP ratio of each country. Table 5 shows the results from these regressions. We find a positive and significant relationship between the share of educated workers in a firm and a firm's assets. The positive and significant coefficient on firms' assets however is smaller in countries with higher domestic credit to GDP ratios. From

Table 5: Firm-level regressions: model and data

	Data			Model		
Log of firm's assets	3.395***			2.767***		
	[2.92,4.19]			[2.761,2.773]		
Log of firm's assets ×						
domestic credit/GDP	-0.021***	Min(18)	Max(123)	-0.015***	Min(7)	Max(155)
	[-0.03,-0.01]	3.17	0.93	[-0.015,-0.016]	2.66	0.37
Country dummies	X			X		
Industry dummies	X					
Observations	6135			2,010,083		
R-squared	0.429			0.909		

*Notes: T-statistics are shown in brackets.*** indicates significance at the 1% level, ** indicates significance at 5% level, and * indicates significance at the 10% level. Dependent variable is the % of workers with >10 years education in the population. Using simulated data each firm is weighted by its mass.*

the minimum to the maximum value of domestic credit to GDP, the slope coefficient varies between 3.17 and 0.93. This indicates that, particularly in countries with low financial development, firms with more assets employ a higher fraction of educated workers. We reproduce this regression in the model and estimate similar coefficients and a similar slope varying from 2.66 to 0.37.

5 Robustness

We check the robustness of our results along three different dimensions. We first consider an open economy version of our model. Second, we replicate the model assuming a Cobb-Douglas production function, and finally we consider a version of the model where we let individuals decide if they want to acquire an education.

5.1 Open Economy

Our benchmark model considers a closed economy where financial frictions and investment decisions of entrepreneurs affect the equilibrium interest rate and thus savings decisions of individuals. This is different in an (small) open economy where the world interest rate remains constant as financial frictions are removed. To check by how much our results change in such an environment, we consider an open economy version of our model, and we repeat all exercises. Note that we do not have to adjust the calibration of the model.

When changing financial frictions (χ) and educational attainment (θ), we simply keep the interest rate constant at its value from our benchmark calibration (4.5 percent). Appendix B displays all exercises for the open economy version of the model. Throughout the range of simulations, the interaction effect of financial frictions and educational attainment turns out to be as high as 57 percent.

In the open economy version of our model gains from financial development are much lower than in the closed economy version. However, these gains still depend crucially on countries' educational attainments. In particular, output gains of financial development in open economies vary from 2.4 percent in Malawi to 11 percent in Mexico and 17 percent in the Philippines. We find the effects of financial development on wage inequality to be similar to the ones in our baseline economy. Our cross-country regressions also yield similar results. However, the coefficient on firms' assets in the firm level regression of the share of skilled workers is only one third of the one estimated in the data, compared to 82% in our baseline regression.

5.2 Cobb-Douglas production function

We argued that financial frictions and capital-skill complementarity were key elements in our model. In order to check how much capital-skill complementarity contributes to our results we consider a version of our model with a Cobb-Douglas production function. In this case we need to re-calibrate the model (see Tables C.1 and C.2 in Appendix C for this calibration as well as targeted and non-targeted moments). Note that this version of the model does as well as the baseline model in matching both targeted and un-targeted moments of the data.

We then reproduce all our exercises; see Appendix C. If technology were described by a Cobb-Douglas production function, many of our baseline results would be overturned. The main dimension in which such a model fails is the firm level regression of the share of skilled workers on the log of firms' assets. Because with a Cobb-Douglas technology all firms within a country have the same skilled to unskilled labor ratio. Furthermore, financial development alone would have much larger effects on output, and these effects would be larger for countries with lower educational attainment. In our case studies, a financial liberalization would raise output by 29 percent in the Philippines, 33 percent in Mexico and 43 percent in Malawi. Furthermore, the effects of the two reforms would seem rather independent, with an amplification of only 1 percent in the Philippines, 3 percent in Mexico but 38 percent in

Malawi. In addition, financial development would reduce wage inequality, particular when educational attainment is very low.

5.3 Endogenizing educational attainment

Throughout the paper, we have taken both the educational attainment and financial frictions as exogenous. This allowed us to focus on the decomposition of the relative contribution of each factor and their interaction for differences in income. However, given that financial frictions are important drivers behind wage inequality it seem reasonable that changes in financial market development could themselves affect individuals' choices regarding educational attainment. While in the current paper does not aim to rigorously the effects of financial frictions on human capital accumulation, we propose a simple variation of our model that endogenizes educational attainment.

In particular, we assume that prior to entering the labor market, individuals decide whether to invest in higher education, comparing returns to education with the cost of acquiring an education. We assume that individuals calculate their returns to education under the "veil of ignorance"; i.e. they do not anticipate how the number of college graduates or financial market reforms could affect returns to education in the future. Furthermore, we assume that the cost of education c is drawn from a lognormal distribution G with mean μ and variance σ. We denote by V^s and V^u the values of having or not acquired higher education respectively. In equilibrium, there will be a threshold cost, c^* above which people decide not to obtain higher education. At the threshold cost, individuals are indifferent and hence $V^s - V^u = c^*$. The fraction of individuals with higher education then becomes endogenous, and is given by

$$\theta = G(V^s - V^u). \tag{8}$$

In this version of our model, Equation 8 is hence added to the previous four equilibrium conditions. Note that this model has two additional parameters that need to be calibrated, the mean and variance of the distribution from which the costs of acquiring an education are drawn. We match the fraction of college graduates (which was previously exogenous) to calibrate the mean of this distribution, and we choose the variance to target an average spending on tertiary education in the US of 2.6 percent of GDP (taken from OECD Statistics). Appendix D shows the results.

We find that varying financial frictions from autarky to perfect capital markets, can explain a variation of educational attainment of 2 percentage points. This amplifies marginally the effects of financial frictions, but the effect is quantitatively small.

6 Conclusion

Capital-skill complementarity in production implies non-trivial interactions between firms' availability of human and physical capital. This has important implications for economic development, as gains from financial deepening depend on countries' educational attainment. We show that these gains are very small when educational attainment is low. Additionally, we find that there are substantial synergies of implementing educational and financial reforms jointly. To obtain our results, we carry out an accounting exercise rather than a horse race because we think that there are many other channels outside the scope of our model that make both financial frictions and educational attainment endogenous. Our approach is also positive, rather than normative, and hence our results do not suggest that one reform is preferable to the another. To be able to make such statements would require precise estimates of the costs of each reform including how long it would take to implement them. We leave this type of analysis for future work.

We also find that financial frictions are an important driver of wage inequality, raising wages of skilled workers two to four times more than wages of unskilled workers. Besides the literature on capital-skill complementarity, there also exists a large literature on the complementarity between technology and skilled labor, see for instance Acemoglu [1998]. Our result regarding the asymmetric effects of financial development for skilled and unskilled wages raises an interesting question. Depending on the estimation procedure and controls used, it is possible that previous literature might have attributed increases in wage inequality to skill-biased technological change instead of financial market development. We leave an investigation into this hypothesis for future research.

Our paper also has implications for the literature studying the economic effects of resource misallocation. We show that one way to make interference about the misallocation of resources is by studying how the skill composition of a firm differs from that of the average firm in the sector. In particular, if the skill-unskilled labor ratio of a firm is lower than the sector average, this might be an indicator that a firm is financially constrained and cannot operate at its desired level of capital.

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COMPANION APPENDIX

Human capital and Financial Development: Firm-Level Interactions and Macroeconomic Implications

Lian Allub, Pedro Gomes and Zoë Kuehn

A Additional results

A.1 Deriving the entrepreneur's optimal decisions

The first-order conditions of the entrepreneur's problem are:

$$z_i^{(1-\gamma)}\gamma X_i^{\frac{\gamma}{\sigma}-1}[\lambda(k_i)^\rho+(1-\lambda)(n_i^s)^\rho]^{\frac{\sigma}{\rho}-1}](1-\lambda)(1-\mu)(n_i^s)^{\rho-1}=w^s, \tag{A.1}$$

$$z_i^{(1-\gamma)}\gamma X_i^{\frac{\gamma}{\sigma}-1}\mu(n_i^u)^{\sigma-1}=w^u, \tag{A.2}$$

$$z_i^{(1-\gamma)}\gamma X_i^{\frac{\gamma}{\sigma}-1}[\lambda(k_i)^\rho+(1-\lambda)(n_i^s)^\rho]^{\frac{\sigma}{\rho}-1}]\lambda(1-\mu)k_i^{\rho-1}=r_i, \tag{A.3}$$

where $X_i=[\mu(n_i^u)^\sigma+(1-\mu)[\lambda(k_i)^\rho+(1-\lambda)(n_i^s)^\rho]^{\frac{\sigma}{\rho}}]$ and $r_i=r+\Lambda_i$. Combining equations A.1 and A.2 we obtain:

$$\frac{w^u}{w^s}=\frac{\mu}{1-\mu}\frac{(n_i^u)^{\sigma-1}}{[\lambda(k_i/n_i^s)^\rho+(1-\lambda)]^{\frac{\sigma}{\rho}-1}(1-\lambda)(n_i^s)^{\sigma-1}}, \tag{A.4}$$

and Equations A.1 and A.3 provide us with the optimal ratio of capital to skilled labor:

$$\frac{k_i}{n_i^s}=\left[\frac{\lambda}{1-\lambda}\frac{w^s}{r_i}\right]^{\frac{1}{1-\rho}}\equiv B_i. \tag{A.5}$$

Combining the expressions above we arrive at the entrepreneur's optimal ratio of skilled to unskilled labor:

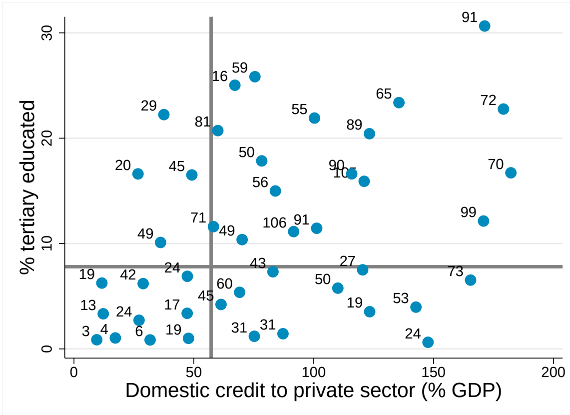
$$\frac{n_i^s}{n_i^u}=\left[\frac{w^u}{w^s}\frac{(1-\lambda)(1-\mu)[\lambda(\frac{\lambda w^s}{(1-\lambda)r_i})^{\frac{\rho}{1-\rho}}+(1-\lambda)]^{\frac{\sigma-\rho}{\rho}}}{\mu}\right]^{1/(1-\sigma)}\equiv A_i. \tag{A.6}$$

Finally, re-writing $X_i=\left[\frac{\mu}{A_i^\sigma B_i^\sigma}+(1-\mu)\left(\lambda+\frac{(1-\lambda)}{B_i^\rho}\right)^{\frac{\sigma}{\rho}}\right]k_i^\sigma$, we obtain the entrepreneur's optimal capital-output ratio:

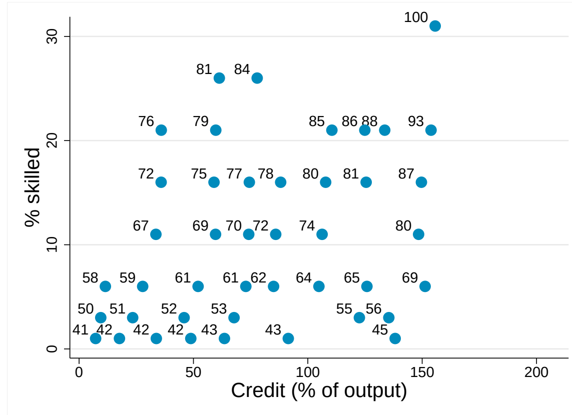
$$\frac{k_i}{y_i}=\frac{\gamma}{r_i}\frac{\lambda(1-\mu)\left(\lambda+\frac{(1-\lambda)}{B_i^\rho}\right)^{\frac{\sigma}{\rho}-1}}{\left[\frac{\mu}{A_i^\sigma B_i^\sigma}+(1-\mu)\left(\lambda+\frac{(1-\lambda}{B_i^\rho}\right)^{\frac{\sigma}{\rho}}\right]}. \tag{A.7}$$

Figure A.1: Cross-country statistics: data and model

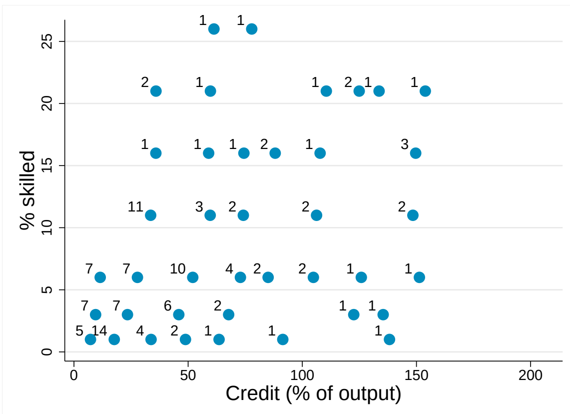
GDP per capita relative to the US (Data)



GDP per capita relative to the US (Model)



Number of countries included in each point



% of explained GDP gap

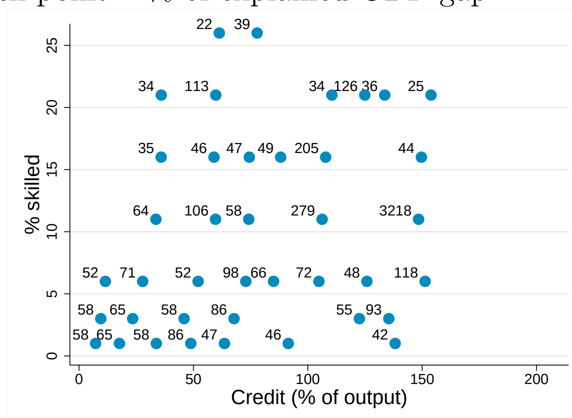
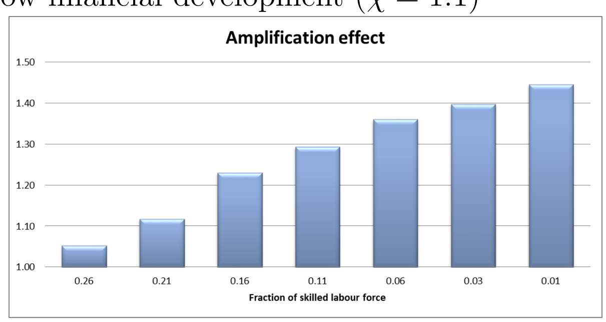
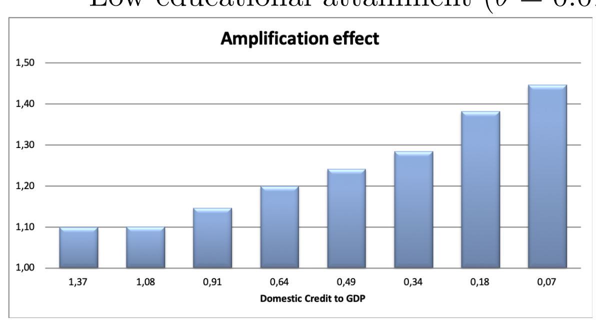


Figure A.2: Amplification of joint reforms on output

Low financial development ($\chi = 1.1$)



Low educational attainment ($\theta = 0.01$)



Notes: Based on model simulations. The graphs plot the contribution of the interaction effect of financial liberalizations and education reforms carried out jointly to explain differences in GDP relative to the US. The left hand graph starts at $\chi = 1.1$ with different values of θ. The right hand graph starts at $\theta = 0.01$ with different values of χ.

Table A.1: Cross-country regressions of GDP per capita with quadratic terms

	Data		**Model**	
Domestic credit to GDP				
Linear	0.694***	[0.253,1.137]	0.016	[-0.0402,0.0724]
Quadratic	-0.0037**	[-0.0066,-0.0009]	0.109	[-0.0001,0.0006]
% of tertiary educated				
Linear	4.641***	[1.937,7.346]	2.7549***	[2.5151,2.9948]
Quadratic	-0.2275***	[-0.3541, -0.1008]	-0.0541***	[-0.0611,-0.0471]
Domestic credit ×				
% tertiary	0.0281**	[0.0033,0.0529]	0.003***	[0.0019,0.0045]
Observation	131		72	
R-squared	0.407		0.978	

*Notes: The 95 confidence intervals are shown in brackets.*** significance at the 1% level, ** significance at 5% level, and * significance at the 10% level. For each country the data is the average for the period 1995-2005.Sources: GDP per capita PPP, Domestic Credit to GDP from World Bank Development indicator; Educational attainment from Barro and Lee [2013].*

Table A.2: Cross-country regressions, weighted

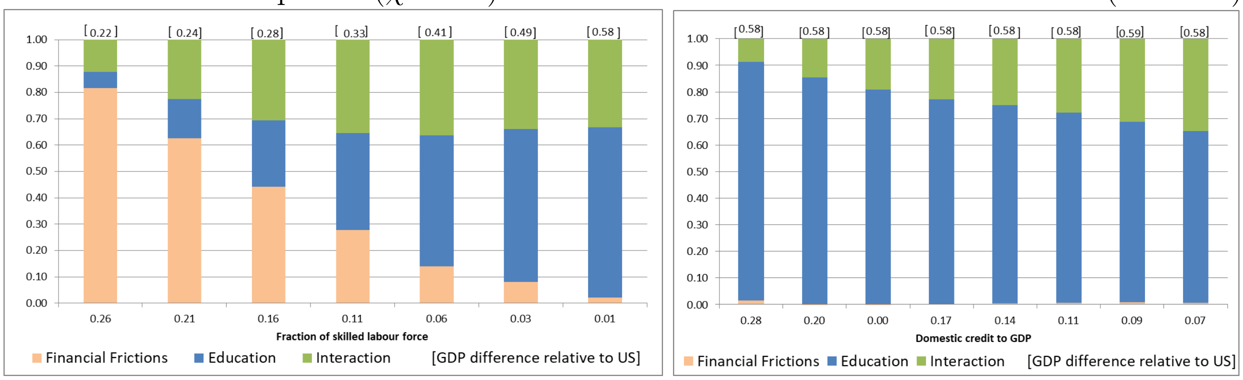
	Data			**Model**	
	Domestic Credit to GDP	% of tertiary educated	Obs. (R^2)	Domestic Credit to GDP	% of tertiary educated
GDP per capita	0.339***	1.482***	131	0.121***	1.737***
(relative to US)	[0.18,0.49]	[0.41,2.55]	(0.33)	[0.049, 0.193]	[1.442,2.032]
TFP	0.269***	0.690*	67	0.063**	1.139***
(relative to US)	[0.16,0.37]	[-0.04,1.42]	(0.50)	[0.006, 0.120]	[0.906, 1.372]
Firm size	0.0051**	0.0155	97	0.001	-0.0065***
(logs)	[0.001,0.010]	[-0.01,0.04]	(0.10)	[-0.0003, 0.0019]	[-0.0111, -0.0019]
College premium	0.002**	-0.02**	97	-0.0006	-0.105***
(logs)	[0.000,0.005]	[-0.04,-0.003]	(0.08)	[-0.005, 0.003]	[-0.123, -0.086]

*Notes: The 95 confidence intervals are shown in brackets.*** significance at the 1% level, ** significance at 5% level, and * significance at the 10% level. For each country the data is the average for the period 2004-2016. Sources: GDP per capita PPP, Domestic Credit to GDP from World Bank Development indicator; Educational attainment from Barro and Lee [2013]; TFP from Buera and Shin [2013]; Firm size in logs from Enterprise survey; College premium in logs takes from ILO (ratio of average wage in occupation Professionals over Plant and machine operators, and assemblers). In the model regressions, each observation (grid point) is weighted by the number of countries in the same grid point in the data equivalent (shown in the bottom left graph of Figure A.1).*

B Robustness: Open Economy

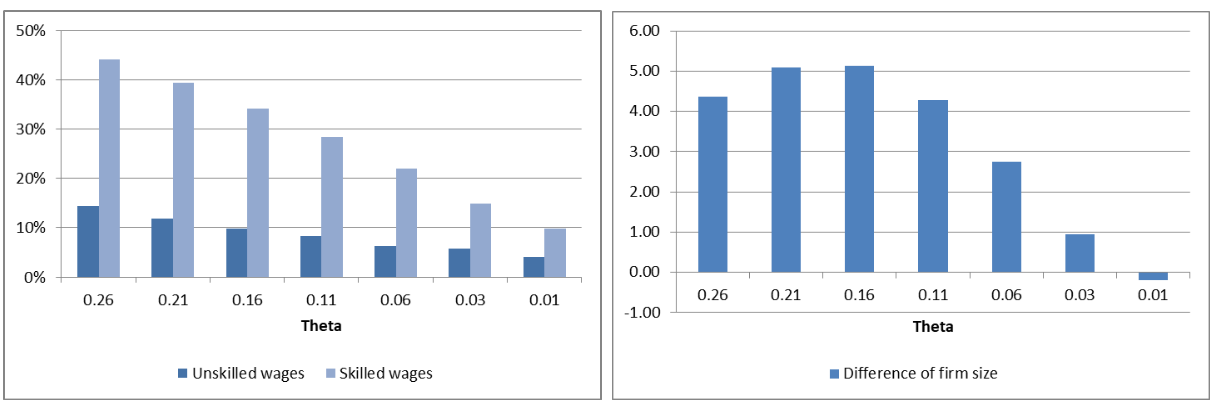
Figure B.1: Open Economy - effects of financial frictions and educational attainment on output

Low financial development ($\chi = 1.1$) Low educational attainment ($\theta = 0.01$)



Notes: Based on simulations of the open economy version of our model. The graphs plot the contribution of each factor (financial frictions, educational attainment and their interaction) to explain differences in GDP relative to the US. The left hand graph starts at $\chi = 1.1$ with different values of θ. The right hand graph starts at $\theta = 0.01$ with different values of χ. Numbers in brackets indicate GDP difference relative to the US. The last columns of the two graphs are equal.

Figure B.2: Open Economy - effects of removing financial frictions on wage inequality and firm size



Notes: Based on model simulations of the open economy version of our model. Both graphs consider a situation where financial markets develop from $\chi = 1.1$ to $\chi = \infty$ for different levels of educational attainment, θ. The left hand graph displays how skilled and unskilled wages change whereas the right hand graph shows how average firm size is affected.

Table B.1: Open Economy: Three case studies

	Mexico	**Philippines**	**Malawi**
Share of college educated	$\theta = 0.11$	$\theta = 0.21$	$\theta^s = 0.01$
Financial frictions	$\xi = 1.38$	$\xi = 1.38$	$\xi = 2.001.1$
Output model	0.498	0.564	0.303
Output with $\theta = 0.31$	0.595	0.595	0.626
Output with $\chi = \infty$	0.553	0.657	0.310
Gains from education reform	**19.6 %**	**5.5 %**	**107.0 %**
Gains from financial reform	**11.1 %**	**16.5 %**	**2.4 %**
Sum of both reforms	**30.7 %**	**21.9 %**	**109.3 %**
Output US in the model	0.723	0.723	0.723
Both reforms jointly	**45.3 %**	**28.1 %**	**138.8 %**
Output relative to US data	**0.32**	**0.11**	**0.02**
Output relative to US model	**0.69**	**0.78**	**0.42**

Table B.2: Open Economy: Cross-country regressions

	Data			**Model: Open Economy**	
	Domestic Credit to GDP	% of tertiary educated	Obs. (R^2)	Domestic Credit to GDP	% of tertiary educated
GDP per capita	0.339***	1.482***	131	0.146***	1.134***
(relative to US)	[0.18,0.49]	[0.41,2.55]	(0.33)	[0.112, 0.180]	[1.011,1.257]
TFP	0.269***	0.690*	67	0.012*	0.349***
(relative to US)	[0.16,0.37]	[-0.04,1.42]	(0.50)	[-0.001, 0.024]	[0.304, 0.394]
Firm size	0.0051**	0.0155	97	0.0013***	-0.0076
(logs)	[0.001,0.010]	[-0.01,0.04]	(0.10)	[0.0008, 0.0018]	[-0.0096, -0.0057]
College premium	0.002**	-0.02**	97	0.001	-0.082***
(logs)	[0.000,0.005]	[-0.04,-0.003]	(0.08)	[-0.002, 0.003]	[-0.091, -0.072]

*Notes: The 95 confidence intervals are shown in brackets.*** significance at the 1% level, ** significance at 5% level, and * significance at the 10% level. For each country the data is the average for the period 1995-2005. Sources: GDP per capita PPP, Domestic Credit to GDP from World Bank Development indicator; Educational attainment from Barro and Lee [2013]; TFP from Buera and Shin [2013]; Firm size in logs from Enterprise survey; College premium in logs takes from ILO (ratio of average wage in occupation Professionals over Plant and machine operators, and assemblers).*

Table B.3: Open Economy: Firm-level regressions

	Data			**Model: Open Economy**		
Log of firm's assets	3.395***			1.090***		
	[2.92,4.19]			[1.083, 1.096]		
Log of firm's assets ×						
domestic credit/GDP	-0.021***	Min(18)	Max(123)	-0.0046***	Min(7)	Max(155)
	[-0.03,-0.01]	3.17	0.93	[0.0016,0.0022]	1.08	0.37
Country dummies	X			X		
Industry dummies	X					
Observations	6135			614,953		
R-squared	0.429			0.948		

*Notes: T-statistics are shown in brackets.*** indicates significance at the 1% level, ** indicates significance at 5% level, and * indicates significance at the 10% level. Dependent variable is the % of workers with >10 years education in the population. Using simulated data each firm is weighted by its mass.*

C Robustness: Cobb-Douglas production function

Table C.1: Calibration of model with a Cobb-Douglas production function

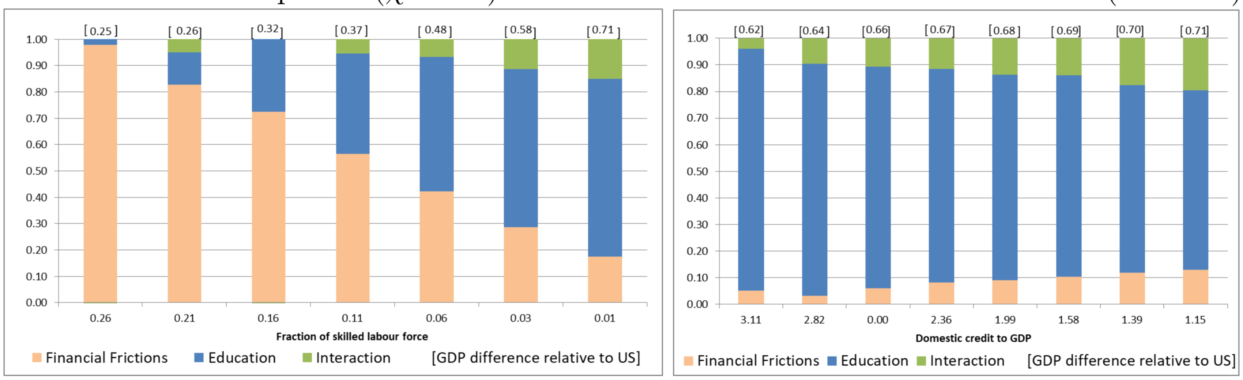
Parameters set exogenously	**Baseline**	**Cobb-Douglas**	**Source**
Depreciation rate (δ)	0.060	0.060	Buera and Shin [2013]
Risk aversion (ψ)	1.5	1.5	Buera and Shin [2013]
Prob. of drawing a new ability	0.106	0.106	Buera and Shin [2013]
Fraction of skilled	0.31	0.31	Barro and Lee [2013]
Tightness of financial friction (χ)	∞	∞	normalization
Substitutability			
Capital and skilled labor (σ)	0.401	0.0001	Krusell et al. [2000]
Capital and unskilled labour (ρ)	-0.495	-0.0001	Krusell et al. [2000]
Calibrated parameters	**Baseline**	**Cobb-Douglas**	**Target**
Span-of-Control (γ)	0.87	0.87	Profits to GDP ratio
Discount factor (β)	0.929	0.928	Real interest rate
Production function			
Weights			
Unskilled labor in production (μ)	0.4385	0.433	College premium
Capital in Production (λ)	0.619	0.426	Capital-output ratio
Distribution of ability			
Shape parameter (α)	1.047	1.021	Mean establishment size
Scale parameter (ξ)	0.426	0.0715	Relative size establishment unskilled-skilled manager

Table C.2: Calibration targets with a Cobb-Douglas production function

Targeted moments	**Source**	**Data**	**Baseline**	**Cobb-Douglas**
Profits to GDP ratio	BEA	0.13	0.13	0.13
Real interest rate	Buera and Shin [2013]	0.045	0.045	0.045
Mean establishment	US Census	17.46	17.49	17.49
Relative size establishment skilled manager	SBO(2007)	0.70	0.70	0.69
Capital-output-ratio	Kamps [2006]	2.00	2.00	2.00
College Premium 2000	Goldin and Katz [2009]	0.63	0.63	0.63
Non-targeted moments	**Source**	**Data**	**Baseline**	**Cobb-Douglas**
Establishment share, < 10 employees	US Census	0.70	0.538	0.538
Establishment share, $10 - 19$ employees	US Census	0.14	0.226	0.226
Establishment share, $20 - 99$ employees	US Census	0.13	0.226	0.226
Establishment share, > 100 employees	US Census	0.03	0.009	0.009
Employment share, < 10 employees	US Census	0.15	0.204	0.196
Employment share, $10 - 19$ employees	US Census	0.10	0.164	0.160
Employment share, $20 - 99$ employees	US Census	0.30	0.388	0.386
Employment share, > 100 employees	US Census	0.45	0.244	0.259
Domestic Credit/GDP	WDI (2000)	1.62	1.56	1.56
Labor share	BEA	0.63	0.66	0.66
Self-employment rate	OECD	0.07	0.05	0.05

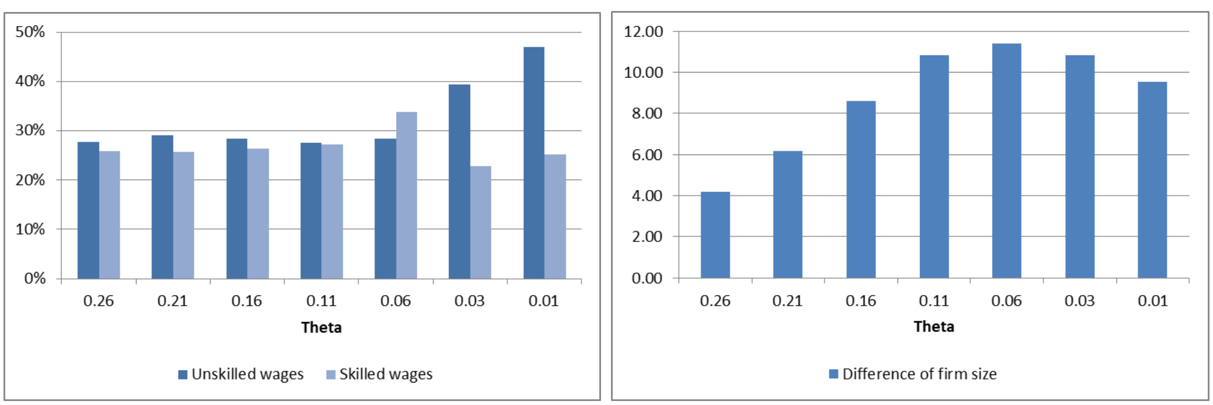
Figure C.1: Cobb-Douglas- effects of financial frictions and educational attainment on output

Low financial development ($\chi = 1.1$)   Low educational attainment ($\theta = 0.01$)



Notes: Based on simulations of the version of our model with a Cobb-Douglas production function. The graphs plot the contribution of each factor (financial frictions, educational attainment and their interaction) to explain differences in GDP relative to the US. The left hand graph starts at $\chi = 1.1$ with different values of θ. The right hand graph starts at $\theta = 0.01$ with different values of χ. Numbers in brackets indicate GDP difference relative to the US. The last columns of the two graphs are equal.

Figure C.2: Cobb-Douglas - effects of removing financial frictions on wage inequality and firm size



Notes: Based on simulations of the version of our model with a Cobb-Douglas production function. Both graphs consider a situation where financial markets develop from $\chi = 1.1$ to $\chi = \infty$ for different levels of educational attainment, θ. The left hand graph displays how skilled and unskilled wages change whereas the right hand graph shows how average firm size is affected.

Table C.3: Cobb-Douglas production function: Three case studies

	Mexico	**Philippines**	**Malawi**
Share of college educated	$\theta = 0.11$	$\theta = 0.21$	$\theta^s = 0.01$
Financial frictions	$\xi = 1.13$	$\xi = 1.18$	$\xi = 1.101.1$
Output model	0.316	0.372	0.144
Output with $\theta = 0.31$	0.387	0.391	0.385
Output with $\chi = \infty$	0.419	0.478	0.207
Gains from education reform	**22.7 %**	**5.1 %**	**166.6 %**
Gains from financial reform	**32.9 %**	**28.5 %**	**43.3 %**
Sum of both reforms	**55.6 %**	**33.6 %**	**209.9 %**
Output US in the model	0.501	0.501	0.501
Both reforms jointly	**58.7 %**	**34.7 %**	**247.3 %**
Output relative to US data	**0.32**	**0.11**	**0.02**
Output relative to US model	**0.63**	**0.74**	**0.29**

Table C.4: Cobb-Douglas production function: Cross-country regressions

	Data			**Model: Cobb-Douglas**	
	Domestic Credit to GDP	% of tertiary educated	Obs. (R^2)	Domestic Credit to GDP	% of tertiary educated
GDP per capita	0.339***	1.482***	131	0.072***	1.786***
(relative to US)	[0.18,0.49]	[0.41,2.55]	(0.33)	[0.041, 0.103]	[1.579,1.998]
TFP	0.269***	0.690*	67	0.036*	1.663***
(relative to US)	[0.16,0.37]	[-0.04,1.42]	(0.50)	[0.010, 0.062]	[1.486, 1.841]
Firm size	0.0051**	0.0155	97	0.0028***	0.0289
(logs)	[0.001,0.010]	[-0.01,0.04]	(0.10)	[0.0025, 0.0032]	[0.0263, 0.0314]
College premium	0.002**	-0.02**	97	0.001	-0.106***
(logs)	[0.000,0.005]	[-0.04,-0.003]	(0.08)	[-0.001, 0.002]	[-0.117, -0.095]

*Notes: The 95 confidence intervals are shown in brackets.*** significance at the 1% level, ** significance at 5% level, and * significance at the 10% level. For each country the data is the average for the period 1995-2005. Sources: GDP per capita PPP, Domestic Credit to GDP from World Bank Development indicator; Educational attainment from Barro and Lee [2013]; TFP from Buera and Shin [2013]; Firm size in logs from Enterprise survey; College premium in logs takes from ILO (ratio of average wage in occupation Professionals over Plant and machine operators, and assemblers).*

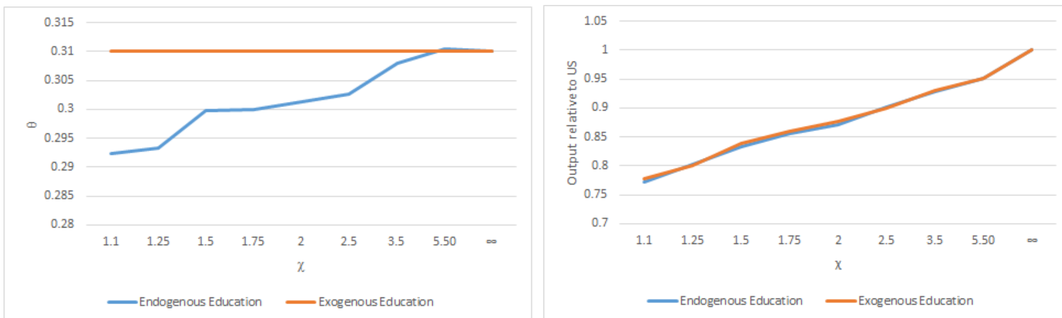
Table C.5: Cobb-Douglas production function: Firm-level regressions

	Data			**Model: Cobb-Douglas**		
Log of firm's assets	3.395***			0.0056***		
	[2.92,4.19]			[1.083, 1.096]		
Log of firm's assets ×						
domestic credit/GDP	-0.021***	Min(18)	Max(123)	-0.00002***	Min(7)	Max(155)
	[-0.03,-0.01]	3.17	0.93	[0.00002,0.00002]	0.01	0.00
Country dummies	X			X		
Industry dummies	X					
Observations	6135			2,273,473		
R-squared	0.429			1.00		

*Notes: T-statistics are shown in brackets.*** indicates significance at the 1% level, ** indicates significance at 5% level, and * indicates significance at the 10% level. Dependent variable is the % of workers with >10 years education in the population. Using simulated data each firm is weighted by its mass.*

D Robustness: Endogenizing educational attainment

Figure D.1: Endogenous Education - effects of removing financial frictions on educational attainment and output



Notes: Based on simulations of the version of our model with endogenous education. Both graphs consider a situation where financial markets develop from $\chi = 1.1$ *to* $\chi = \infty$*. The left hand graph displays how the proportion of skilled individuals evolves with a financial reform for our benchmark economy (exogenous) and the endogenous education economy whereas the right hand graph shows how GDP is affected in each case.*