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 the availability of human capital and financial constraints. Firms that are constrained in their access to finance hire a lower proportion of skilled workers than do unconstrained firms. Conversely, a lack of human capital increases skilled wages, reducing firms' desired capital intensity and thus loosening firms' effective financial constraints. To assess the macroeconomic implications of such firm-level interactions, we build an occupational-choice model with capital-skill complementarity in production, which we calibrate to US data. We vary financial frictions, educational attainment, and total factor productivity across countries, and we quantify how aggregate output, wage inequality, and entrepreneurship are affected by these variations. For aggregate output, the joint effect of both factors is, on average 30 % larger than the sum of the individual effects. Taking the educational attainment of the population as given, in countries with a negligible share of tertiary educated workers and low TFP, financial development has only small effects on aggregate output.

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

Keywords: financial development, financial frictions, capital-skill complementarity, educational attainment, wage inequality, entrepreneurship

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1 Introduction

For economists, the lack of physical capital and its misallocation, together with low levels of human capital, are two of the main drivers of income disparities across countries. Although the impact of financial frictions on countries' aggregate output is typically analyzed separately from the impact of human capital, we argue both sources of economic development should be analyzed jointly. First, a large body of empirical evidence points to capital and skilled labour as complements in production, a view that has become widely accepted in macroeconomics (Griliches [1969]; Krusell et. al [2000]).[1] Second, although both educational attainment and domestic credit are positively related to per-capita-gdp, as displayed in Figure 1, these relationships are stronger for countries with more developed financial markets and higher educational attainment, respectively.[2]

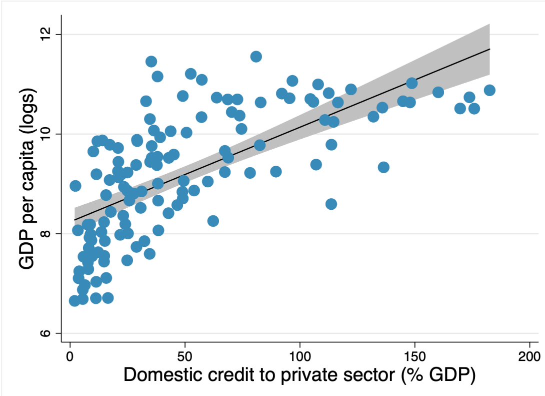
We aim to quantitatively assess the interaction between the effects of developing financial markets and increasing educational attainment for economic growth, when production at the firm level features capital-skill complementarity. To this end, we build an occupational-choice model in which skilled and unskilled individuals, with different levels of managerial ability and wealth, decide to set up a firm or work as employees. Individuals may accumulate assets but can only borrow up to a certain fraction of their wealth. Production uses capital, skilled labour and unskilled labour as inputs. The model features a two-way interaction between financial frictions and education. On the one hand, under capital-skill complementarity, firms with limited access to capital can invest less in equipment and because of this hire fewer engineers than unconstrained firms. On the other hand, scarcity of human capital exerts pressure on skilled wages, reducing firms' desired capital intensity and thus loosening effective financial constraints. Even if firms have access to funding, if engineers are scarce, firms invest less because hiring skilled labour to operate equipment is costly.

To discipline our model, we calibrate it to US data. In our main decomposition exercise we vary financial frictions, educational attainment, and total factor productivity (TFP) across

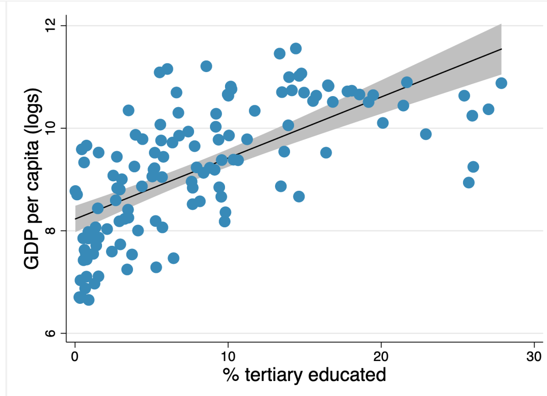
[1] Goldin and Katz [2009] document capital-skill complementarity across US sectors for the early 20th century whereas more recent evidence can be found in Perez-Laborda and Perez-Sebastian [2020].

[2] Table A1 in the Appendix presents the results from cross-country regressions of GDP per capita (relative to the US) on domestic credit and the share of tertiary educated individuals, their quadratic terms, as well as on the interaction of both variables. The coefficients of the linear terms are both positive and statistically significant, meaning the positive association shown in Figure 1, also holds conditionally. The coefficients of the quadratic terms are both negative and statistically significant, suggesting their returns are diminishing. Crucially, the interaction term is positive and significant at the 5% level, and it is also economically meaningful. The marginal effect of an increase in domestic credit on GDP per capita is almost twice as large when evaluated at the 75th percentile of educational attainment versus the 25th percentile.

Figure 1: Economic development, credit, and human capital



(a)



(b)

Notes: Data for GDP and domestic credit from World Bank Development Indicators [2021]; average 2000-2009; for educational attainment from Barro and Lee [2013] for 2005.

129 countries, and we quantify how removing financial frictions (developing financial markets) and increasing educational attainment affect aggregate output, wage inequality, and entrepreneurship. For aggregate output, the joint effect of developing financial markets and boosting educational attainment is, on average, 30% larger than the sum of the individual effects; and for some countries, it can be twice as large. Thus taking the educational attainment of the population as given, in countries with a negligible share of tertiary educated workers and low TFP, relaxing financial frictions has only small effects on aggregate output. This result can explain why some episodes of financial development were more successful (e.g., East Asian countries) than others (e.g., Latin American countries). Similarly, our model generates lower output gains from education expansions when financial frictions are high. The macroeconomic impact of increasing the number of college graduates is rather limited when access to credit is restricted and firms are unable to invest in new equipment. In addition, we show financial market liberalizations lead to higher wage inequality and positively selected entrepreneurs among the skilled workforce, and we present some suggestive evidence that these relationships also hold in the data. Looking at microdata from the World Bank Enterprise survey, we provide support for the existence of our model's firm-level interactions in the data.

Our model focuses on the interaction between financial frictions and human capital from a firm's demand-side perspective, taking the educational attainment of a country as given. This approach is different from the more widely studied mechanism that highlights supply-side interactions whereby financial frictions limit the accumulation of human capital and generate poverty traps (see, e.g., Mestieri *et al.* [2017] or Castro and Ševčík [2017]). By taking the relative supply of skilled workers as given, in our model, financial development has substantial effects on wage inequality. The intuition is that by increasing capital intensity at the firm level, demand for skilled workers increases more than for unskilled workers, hence raising skilled wages more than unskilled wages. If we were to eliminate financial frictions across 129 countries, skilled wages would increase by 31% on average but unskilled wages by only 4.9%. Hence, in a model with endogenous education, we would expect financial development to boost educational attainment, not only by facilitating access to credit for prospective college students, but also by raising returns to education.

To the best of our knowledge, only four other papers highlight the demand-side interactions between financial frictions and education. In a real business-cycle model, Lopez and Olivella Moppett [2012] analyze how shocks to financial frictions affect firms' optimal mix of skilled and unskilled labour along the business cycle. Whereas their aim is to replicate the counter-cyclicality of hours worked by skilled labour relative to unskilled labour, we focus on the steady-state effects of financial development with heterogeneous firms facing capital-skill complementarity in production. Larrain [2015] provides a partial-equilibrium model with an aggregate production function similar to Krusell et. al [2000] to show how capital-skill complementarity implies theoretically that increases in the available capital stock lead to higher wage inequality. He then tests these predictions empirically, showing how countries that open up their capital accounts experience more wage inequality. Although this mechanism is also present in our model, we microfound financial frictions and consider the general-equilibrium implications of changes in wages and interest rates, in particular on the occupational choices of skilled and unskilled individuals and their selection into entrepreneurship. Berniell [2021] sets up a rich theoretical model of informality, occupational choice, and investments in human capital with credit frictions but does not provide any quantitative analysis. Closest to our paper, Fonseca and Van Doornik [2022] 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 – a finding that validates the main mechanism of our paper. The authors set up a two-period model with a fixed number of firms that features capital-skill complementarity in production. However, their paper does not speak to the effects of financial frictions and educational attainment on entrepreneurship or aggregate output across countries.[3]

[3]Two purely empirical papers that study the differential effects of credit-supply shocks on firms' hiring of workers with different levels of education are Berton *et al.* [2018] and Barbosa *et al.* [2019].

Although research on firm-level interactions between financial frictions and human capital is scant, each separate strand of the literature is quite large. Buera *et al.* [2015] provide an excellent overview of the literature on financial frictions that focuses on their effect on firm productivity.[4] Directly related to our paper, Allub and Erosa [2019] add own-account workers to a model of occupational choice and financial frictions. In their model, which abstains from capital-skill complementarity, reducing financial frictions leads to fewer own-account workers, more employers, and larger firms. Buera *et al.* [2011] in an occupational choice model and Midrigan and Xu [2014] in a model of firm exit and entry analyze the effects of financial frictions in economies with two sectors. In both studies, relaxing financial frictions allows entrepreneurs to pay the fixed operating costs for the more productive sector, which increases the sector's size, leading to gains in aggregate output.[5] In our one-sector model, the positive effects of financial development on the extensive margin of entrepreneurship are rather small quantitatively, but different from these papers, we generalize the production function to include skilled and unskilled labour as inputs and to feature capital-skill complementarity.[6]

Within the second strand of literature, recent papers by Gennaioli *et al.* [2013], Erosa *et al.* [2010], Roys and Seshadri [2014], Poschke [2018], Gil *et al.* [2019], and Gomes and Kuehn [2017] study how human capital affects economic development via its effects on firm productivity. We contribute to this literature with one important insight. We show the magnitude of the positive effect of human capital on aggregate output via firm productivity depends crucially on the development of a country's financial markets. On average, across 129 countries, having fully developed financial markets implies that a given increase in the fraction of tertiary educated individuals would lead to 47% larger gains in aggregate output. Comparing our results with an alternative model specification that considers a Cobb-Douglas production function, we show capital-skill complementarity in production is crucial for obtaining these interaction effects.

The remainder of this paper is organized as follows: The next section presents our model. In section 3, we present the calibration and carry out two exercises that highlight the model's mechanisms. Section 4 presents and discusses the findings from our main exercise of vary-

[4] Prominent examples include Cabral and Mata [2003], Erosa [2001], Hsieh and Klenow [2009], and, more recently, Cavalcanti et al. [2019].

[5] In a two-sector model, Feng and Ren [2021] estimate relatively small output gains from relaxing financial frictions in developing countries when accounting for the high share of own-account workers among entrepreneurs.

[6] Our paper also relates to a broader literature that has proposed other explanations as to why average firm productivity differs across countries, for example, policy aspects (e.g. Guner *et al.* [2008]) or informality (e.g. Antunes and Cavalcanti [2007]).

ing financial frictions, TFP, and educational attainment across 129 countries. Section 5 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 managerial abilities and their asset holdings, and who decide to become workers or entrepreneurs. Given their labour and capital income, individuals decide each period how much to consume and to save. Entrepreneurs produce a homogeneous good using skilled and unskilled labour, capital, and their own abilities as inputs. As is typical in these models, under perfect capital markets, only skill levels and managerial abilities determine individuals' occupational choices, whereas under imperfect capital markets, asset holdings also play a role. Because we focus on steady states, and for clarity of exposition, we omit the time subscript t from the description of our model.

Endowments Each individual is endowed with one unit of productive time which he supplies inelastically either to the market if the individual is a worker or to his firm if he is an entrepreneur. Individuals differ in their skill levels as workers e, where $e = s, u$ (skilled, unskilled) and in their managerial abilities, z_i, distributed in $Z = [0, \overline{z}]$, and with cdf $F(z_i)$ and density $f(z_i)$.[7] With a certain probability ζ, individuals draw a new value for managerial ability each period.[8] Individuals hold assets a_i, reflecting their past consumption-savings decisions. The joint cumulative distribution function of assets and managerial ability for each skill type is denoted by $G_e(z_i, a_i)$.

[7] Using a similar production function but abstaining from financial frictions, Gomes and Kuehn [2017] allow for more educated individuals to draw their managerial abilities from a better distribution. But once calibrated,these distributions are quite similar by education. To keep our mechanisms more transparent, we prefer that all individuals draw their managerial ability from the same distribution, although we acknowledge the effects of education expansions might be larger if they also improve the distribution of managerial ability. If lack of human capital also implied lower managerial abilities, financial frictions would be less binding for an additional reason.

[8] New draws for managerial ability are a shortcut for introducing firm dynamics into the model, something we consider to be outside the scope of our paper. We follow Buera and Shin [2013], who point out that these draws are needed for financial frictions to have long-run effects on output, because if individuals' managerial abilities were constant over time, all entrepreneurs would accumulate enough wealth to operate on an unconstrained scale.

Production Each entrepreneur, i, has access to the same technology. He hires unskilled workers l_i, skilled workers h_i, and rents capital k_i. Firms produce a single good according to the following CES production function:

$$y_i(l_i, h_i, k_i) = Az_i^{(1-\gamma)}[\mu l_i^\sigma + (1-\mu)[\lambda(qk_i)^\rho + (1-\lambda)h_i^\rho]^{\frac{\sigma}{\rho}}]^{\frac{\gamma}{\sigma}}, \tag{1}$$

where $\rho \in (-\infty, 1)$ and $\sigma \in (-\infty, 1)$ govern the elasticities of substitution between inputs, μ is the share of unskilled labour in production, and λ is the share of capital in the composite input. In particular, $1/(1-\sigma)$ defines the elasticity of substitution between capital and skilled labor, whereas the elasticities of substitution between capital and unskilled labor and between skilled and unskilled labor are both given by $1/(1-\rho)$. For capital to be more complementary with skilled labor than with unskilled labour, $\sigma > \rho$ has to hold. A is TFP and q denotes the inverse of the price of capital. The presence of decreasing returns to scale on the marketable inputs implies the existence of entrepreneurial profits that depend on managerial ability (z_i).

Imperfect capital markets Contract enforcement problems limit the amount of borrowing. Entrepreneurs are only able to borrow an amount equivalent to χ times their asset holdings. The parameter $\chi \in [1; \infty]$ thus represents the strength of legal institutions in the economy, with $\chi = 1$ indicating absent financial markets. On the other hand, as χ approaches ∞, we converge to an economy with perfect capital markets and without any borrowing limits.

Entrepreneurs Entrepreneurs choose the number of skilled and unskilled workers, as well as the amount of capital to maximize their firms' profits. Given skilled and unskilled wages (w^s, w^u) and a gross rental rate for capital (r), the entrepreneur's problem is given by

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

subject to technology (equation 1) and the collateral constraint: $k_i \leq \chi a_i$. The first-order conditions of the entrepreneur's problem are

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

where $r_i = r + \omega_i$, and with ω_i denoting the multiplier on the collateral constraint. Entrepreneurs hire skilled and unskilled labour until their marginal productivities equal the respective wage rates. If the collateral constraint is not binding, $r_i = r$ and firms hire capital up to the point where its marginal productivity equals the gross rental rate. If the collateral constraint is binding, the multiplier is positive ($\omega_i > 0$), firms use lower levels of capital, and its marginal productivity is higher compared with the unconstrained case.

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

$$E \sum_{t=0}^{\infty} \beta^t \frac{(c_t^i)^{1-\psi}}{1-\psi}, \tag{4}$$

where c_t^i denotes the consumption of individual i at time t, and $\beta \in (0,1)$ is the discount factor. The parameter $\psi \geq 1$ determines individuals' degree of risk aversion. The individual chooses consumption, savings, and occupation to maximize equation (4), subject to the individual's budget constraint

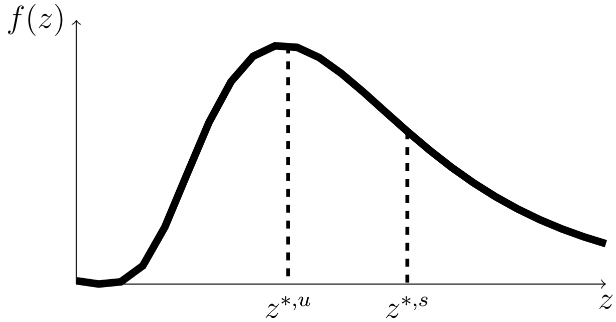
$$\begin{aligned} c_i + a_i' &= I_{z_i(a_i) < z^{*,e}(a_i)}(w^e + \tilde{r} a_i) + \\ &+ I_{z_i(a_i) \geq z^{*,e}(a_i)}(\pi(z_i, a_i) + \tilde{r} * max[0, (a_i - k_i))]. \end{aligned}$$

We denote by $z^{*,e}(a_i)$ the marginal entrepreneur of skill level 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 net rental rate of capital, $\tilde{r}$, in equilibrium is $\tilde{r} = r - \delta$. 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 thresholds for becoming an entrepreneur for individuals of each skill level, defined implicitly by

$$w^e + \tilde{r} a_i = \pi(z^{*,e}(a_i), a_i) + \tilde{r} * max(0, (a_i - k_i)). \tag{5}$$

This condition is somewhat similar to Lucas's [1978] condition for the "marginal" entrepreneur. Wage payments plus capital income must equal the profits that individuals of skill level e, and with a certain amount of assets, expect to make as entrepreneurs. Note that the threshold is well defined and thus unique given that profits are increasing in managerial ability and wages are not. Figure 2 shows how higher skilled wages translate into a higher threshold

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



for becoming an entrepreneur for skilled individuals. Once managerial abilities are drawn and some individuals choose to become entrepreneurs, their income in terms of profits and capital returns are no longer dependent on their skill levels.

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

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

where ζ is the probability of drawing a new managerial ability z_i, and I is an indicator function for the managerial ability lying above or below the threshold. The value of being a worker today is given by the utility of consumption today and the continuation value of being a worker or becoming an entrepreneur in the future. One can become an entrepreneur in the future in two ways: either by drawing a higher managerial ability or by accumulating enough assets.

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

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

The value of being an entrepreneur today is given by the utility of consumption today and the continuation value of being an entrepreneur or becoming a worker in the future. Entrepreneurs never find it optimal to become workers unless they draw a new, and lower value of managerial ability z_i.

Steady-state equilibrium A steady-state equilibrium in this economy is defined by two time-invariant, joint distributions of individuals' assets and their managerial ability $\{G_u(z_i, a_i), G_s(z_i, a_i)\}$, thresholds for becoming an entrepreneur for skilled and unskilled individuals for each level of assets $\{z^{*,u}(a_i), z^{*,s}(a_i),\}$, labour and capital demands for each firm $h_i(z_i, w^u, w^s, r_i)$, $l_i(z_i, w^u, w^s, r_i)$, and $k_i(z_i, w^u, w^s, r_i)$, a rental rate for capital, wages for skilled and unskilled individuals $\{r, w^u, w^s\}$, and individuals' consumption decisions $\{c_i\}$, such that

1. individuals maximize their utility subject to the budget constraint;
2. entrepreneurs maximize their profits subject to the technology and the collateral constraint;
3. the joint distributions of managerial ability and wealth for unskilled and skilled individuals $G_e(z_i, a_i)$ are fixed points of the equilibrium mapping,

$$G_e(z_i, a_i) = (1-\zeta) \int_{\{(\tilde{z}_i,\tilde{a}_i)|\tilde{z}_i \leq z_i, a_i'(\tilde{a}_i,\tilde{z}_i) \leq a_i\}} G_e(d\tilde{z}_i, d\tilde{a}_i) + \zeta F(z_i) \int_{\{(\tilde{z}_i,\tilde{a}_i)|a_i'(\tilde{a}_i,\tilde{z}_i) \leq a_i\}} G_e(d\tilde{z}_i, d\tilde{a}_i);$$

4. all four markets clear, that is, the two labour markets plus the capital and goods markets.

We denote by θ the share of skilled individuals in the population, which is taken as given.[9] For the skilled labour market to clear, the supply of skilled workers (those skilled individuals who have not become entrepreneurs, given by the left-hand side of the following equation)

[9] In a previous version, we proposed a simple extension with endogenous education (Allub, Gomes, and Kuehn [2019]). We decided against adapting this framework to our current model, because for the interpretation of the counter-factuals whether educational attainment is supply driven (construction of schools, teacher training, class sizes) or demand driven (returns of schooling, financial constraints) matters, but we would only be considering the latter together with an exogenous driving force (a cost of acquiring education). Even if tertiary education might be more demand driven, in many of the countries in our sample, as a prerequisite for tertiary education, secondary educational attainment – a clearer case for supply-side education – is quite low and would need to be increased first and foremost.

has to equal the sum of demands for skilled labour by skilled entrepreneurs (first term on the right-hand side) and by unskilled entrepreneurs (second term on the right-hand side):

$$\begin{aligned}\theta \int_{\{(z_i,a_i)|z_i \leq z^{*,s}(a_i)\}} G_s(dz_i, da_i) &= \theta \int_{\{(z_i,a_i)|z_i \geq z^{*,s}(a_i)\}} h_i(z_i, w^u, w^s, r_i) G_s(dz_i, da_i) \\ &+ (1-\theta) \int_{\{(z_i,a_i)|z_i \geq z^{*,u}(a_i)\}} h_i(z_i, w^u, w^s, r_i) G_u(dz_i, da_i).\end{aligned}$$

Similarly, the labour market for unskilled workers clears when:

$$\begin{aligned}(1-\theta) \int_{\{(z_i,a_i)|z_i \leq z^{*,u}(a_i)\}} G_u(dz_i, da_i) &= \theta \int_{\{(z_i,a_i)|z_i \geq z^{*,s}(a_i)\}} l_i(z_i, w^u, w^s, r_i) G_s(dz_i, da_i) \\ &+ (1-\theta) \int_{\{(z_i,a_i)|z_i \geq z^{*,u}(a_i)\}} l_i(z_i, w^u, w^s, r_i) G_u(dz_i, da_i).\end{aligned}$$

The market-clearing condition for capital is given by

$$\begin{aligned}&K \equiv \theta \int a G_s(dz_i, da_i) + (1-\theta) \int a G_u(dz_i, da_i) = \\ &= \theta \int_{\{(z_i,a_i)|z_i \geq z^{*,s}(a_i)\}} k_i(z_i, w^u, w^s, r_i) G_s(dz_i, da_i) + (1-\theta) \int_{\{(z_i,a_i)|z_i \geq z^{*,u}(a_i)\}} k_i(z_i, w^u, w^s, r_i) G_u(dz_i, da_i).\end{aligned}$$

With $y_i(z_i, w^u, w^s, r_i)$ being the supply of goods by any entrepreneur of ability z_i, the market clearing in the goods market requires the following to hold:

$$\begin{aligned}C + \delta K &= \theta \int_{\{(z_i,a_i)|z_i \geq z^{*,s}(a_i)\}} y_i(z_i, w^u, w^s, r_i) G_s(dz_i, da_i) \\ &+ (1-\theta) \int_{\{(z_i,a_i)|z_i \geq z^{*,u}(a_i)\}} y_i(z_i, w^u, w^s, r_i) G_u(dz_i, da_i).\end{aligned}$$

2.1 Entrepreneurs' optimal decisions

Combining the entrepreneur's first-order conditions (see equation 3), we can derive the following expression for the optimal ratio of skilled to unskilled labour (see Appendix for derivation):

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

This ratio depends on $r_i = r + \omega_i$, which is firm-specific and depends on how closely binding the collateral constraint is. If firms are unconstrained in their access to finance, $r_i = r$, and the right-hand-side of the expression depends only on aggregate prices and parameters. For all unconstrained firms, the skilled-unskilled labour ratio is thus constant and independent of z_i or a_i. On the other hand, for firms that are constrained in their access to finance, the ratio depends on the size of the multiplier and, in turn, on firm characteristics. Whereas our measure of financial market development χ is an aggregate parameter, r_i is endogenous and firm-specific. Financial frictions hence affect firms' optimal skill mix directly, as reductions in χ tighten the collateral constraint, raising r_i for all constrained firms, as well as indirectly through general-equilibrium effects and occupational-choice decisions.

The derivative of the ratio of skilled to unskilled labour with respect to the firm-specific cost of capital r_i is given by

$$sign\left(\frac{\partial(\frac{h_i}{l_i})}{\partial r_i} \right) = sign\left(\frac{\rho - \sigma}{(1-\rho)(1-\sigma)} \right), \tag{7}$$

where $\sigma, \rho < 1$. The sign is negative for the case of capital-skill complementarity in production, $\rho < \sigma$. Hence, entrepreneurs who are more financially constrained and face higher costs of capital hire a lower ratio of skilled to unskilled labour. If $\sigma = \rho$, which includes the case of a Cobb-Douglas production function, entrepreneurs always employ the same ratio of skilled to unskilled labour, independently of their cost of capital. Therefore, financial frictions alone cannot generate any dispersion in this ratio, unless combined with capital-skill complementarity.

We also derive the entrepreneur's optimal ratio of capital to skilled labour $\frac{k_i}{h_i} = \left[\frac{\lambda}{1-\lambda} \frac{w^s}{r_i} \right]^{\frac{1}{1-\rho}} q^{\rho/(1-\rho)} \equiv \Psi_i$, which increases with skilled wages. Finally, the optimal capital-output ratio is

$$\frac{k_i}{y_i} = \frac{\gamma}{r_i} \frac{\lambda q^\rho (1-\mu) \left(\lambda q^\rho + \frac{(1-\lambda)}{\Psi_i^\rho} \right)^{\frac{\sigma}{\rho}-1}}{\left[\frac{\mu}{\Theta_i^\sigma \Psi_i^\sigma} + (1-\mu) \left(\lambda q^\rho + \frac{(1-\lambda}{\Psi_i^\rho} \right)^{\frac{\sigma}{\rho}} \right]}, \tag{8}$$

which depends on the wages of skilled and unskilled workers. This ratio increases with unskilled wages. Hence, everything else equal, as the supply of skilled labour increases and the relative wages of skilled workers decrease, entrepreneurs find it optimal to use more capital. Loosening financial frictions is thus particularly effective in an environment with lower relative skilled wages, that is, a larger supply of skilled workers.

3 Calibration

We calibrate our model to data from the US. Some parameters are set exogenously, based on outside information or as normalizations, whereas others are calibrated to match data moments. Table 1 displays our chosen parameter values. We set the risk-aversion parameter to 1.5 following Buera and Shin [2013] and Chetty [2006], who estimates relative risk aversion in macro-models to lie between 1 and 2. Based on data from the U.S. Bureau of Economic Analysis [2020] on current-cost depreciation of private non-residential fixed assets for 2000-2009, we fix the depreciation rate at 8.2% per year.

The parameters ρ and σ govern the elasticities of substitution between skilled and unskilled labour and capital. Given that our setting cannot be mapped directly to existing work that has proposed different values for these parameters, we calibrate those values by introducing a time-series dimension. We target the evolution of the US college premium at two additional points in time, the 1980s and the 1960s. Between the 1960s and the 2000s, the share of tertiary educated individuals increased considerably, as did the college premium. Over the same period, US financial markets became much more developed. We use the fall in the relative price of capital together with capital-skill complementarity and financial market development to replicate the parallel increase in the college premium and the domestic credit to GDP ratio. To this end, we simulate our economy for three periods (2000s, 1980s, 1960s), adjusting for each decade the relative price of capital obtained from DiCecio [2012], and the educational composition of the population taken from Barro and Lee [2013]. We also calibrate TFP and financial frictions in the 1980s and the 1960s relative to the 2000s to target GDP per capita and domestic credit to GDP, respectively. The fraction of skilled individuals in the 2000s is set to 0.279, equal to the share of the US population above age 25 with completed tertiary education in 2005. We back out the following values for parameters ρ and σ: -0.11 and 0.60, respectively. These parameter values imply elasticities of substitution between capital and skilled labour and capital and unskilled labour of 0.91

Table 1: Baseline calibration

Parameters set exogenously	**Value**	**Source**
Risk aversion (ψ)	1.500	Buera and Shin [2013]
Depreciation rate (δ)	0.082	BEA [2020]
<u>2000s</u>		
Fraction of skilled individuals (θ_{00})	0.279	Barro and Lee [2013]
Inverse price of capital 2000s (q^{00})	1	normalization
TFP 2000s (A_{00})	1	normalization
<u>1980s</u>		
Fraction of skilled individuals (θ_{80})	0.224	Barro and Lee [2013]
Inverse price of capital 1980s (q^{80})	0.571	DiCecio [2012].
<u>1960s</u>		
Fraction of skilled individuals (θ_{60})	0.109	Barro and Lee [2013]
Inverse price of capital 1960s (q^{60})	0.405	DiCecio [2012]
Calibrated parameters	**Value**	**Target**
<u>Production function</u>		
Substitutability		
Capital and unskilled labour (σ)	0.600	College premia 1980s and 1960s
Capital and skilled labour (ρ)	-0.112	College premia 1980s and 1960s
Weights		
Unskilled labour in production (μ)	0.443	College premium 2000s
Capital in Production (λ)	0.612	Labor share
<u>Time series</u>		
Tightness of financial frictions (χ_{00})	∞	Credit-to-GDP 2000s
TFP 1980s (A_{80})	0.963	GDP per capita 1980s
Tightness of financial frictions (χ_{80})	2.379	Credit-to-GDP 1980s
TFP 1960s (A_{60})	0.795	GDP per capita 1960s
Tightness of financial frictions (χ_{60})	2.377	Credit-to-GDP 1960s
<u>Distribution of ability</u>		
Shape parameter (α)	1.007	Mean establishment size
Scale parameter (x_m)	0.448	Relative size establishment unskilled-skilled manager
Span-of-Control (γ)	0.870	Profits-to-GDP ratio
Discount factor (β)	0.932	Real interest rate
Prob. of drawing a new ability (ζ)	0.103	Exit rate

and 2.5, respectively. In section 4.2, we discuss how these numbers compare with those proposed by existing literature and how results change when we assume different elasticities.

We are left with 14 parameters that are calibrated to match 14 data targets. Turning to the parameters of the production function, the weight of capital in production, λ, targets a labour share of 0.61 for the 2000s according to the Bureau of Labor Statstics [2020]. Goldin and Katz [2009] estimate a college premium from the 2000 US Census of 61%. To match this number, μ is calibrated to a value of 0.44. We consider a Pareto distribution for managerial ability, which can be characterized by a shape parameter, or tail index α, and scale parameter x_m. Both skilled and unskilled individuals are assumed to draw their managerial abilities from the same distribution. The parameters of this distribution are calibrated to target two statistics on average firm size. According to the Longitudinal Business Database of the US Census [2021], the mean establishment size for the 2000s was 17.5. The US Census' Survey of Business Owners and Self-Employed Persons [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 unskilled (primary and secondary educated) entrepreneurs was equal to 72% of the size of establishments with skilled entrepreneurs (tertiary educated). We set the scale parameter to 0.44 and the shape parameter to 1.01 to target these numbers. 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 (corporate profits plus proprietors' income weighted by the labour share), taken from the U.S. Bureau of Economic Analysis [2015]. As in Buera and Shin [2013], the value of the discount factor β targets an annual real interest rate of 4.5% We calibrate the probability of drawing a new managerial ability in each period to 0.1028, matching an average firm exit rate of 10% for the 2000s according to the Business Dynamic Statistics of the US Census [2018]. The parameter for financial constraints in the 2000s, χ_{00}, is initially set to match a US credit-to-GDP ratio of 183% as reported in the World Bank Development Indicators (WDI [2021]). However, to target this high credit-to-GDP ratio, we need to set χ_{00} to such a large number that no firm in the economy is ever credit constrained. Hence, we can effectively set χ_{00} to any number large enough to generate perfect financial markets.

Table 2 displays our calibration targets next to the model's statistics and some additional moments that were not targeted. Our model matches most data fairly well. However, even though no agent in our 2000s economy is credit constrained, we are still somewhat underestimating the credit-to-GDP ratio in the US. We also have trouble matching the exact time series of the college premium, but Figure A1 in the Appendix shows that the model is able to capture its overall evolution. Regarding non-targeted moments, the model matches several statistics regarding establishment and employment shares by firm size, except the employment share of large firms, which is only 27 per cent in the model, compared to 45% in the data.[10] Regarding aggregate statistics, in our model, once we target average firm size, the self-employment rate is determined. Targeting an average establishment size of 17.5

[10]This result is mainly due to the value for α close to 1 which implies an infinite variance of the ability distribution. However, values for managerial ability are truncated such that the highest value for managerial ability is assigned to 0.05% of individuals. A commonly used approach for 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 to keep the model simple, we abstain from doing so.

Table 2: Calibration targets and model values, baseline model

Targeted moments	**Source**	**Data**	**Model**
Profits-to-GDP ratio	BEA [2015].	0.13	0.13
Real interest rate	Buera and Shin [2013]	0.045	0.045
Mean establishment size	US Census [2021]	17.53	17.23
Relative size establishment unskilled manager	SBO[2007]	0.72	0.69
Labor share 2000s	BLS [2020].	0.61	0.58
College Premium 2000	Goldin and Katz [2009]	0.61	0.60
College Premium 1980	Goldin and Katz [2009]	0.39	0.21
College Premium 1960	Goldin and Katz [2009]	0.40	0.45
GDP per capita 1980s relative to 2000s	BEA [2018]	0.67	0.66
GDP per capita 1960s relative to 2000s	BEA [2018]	0.43	0.44
Domestic credit to GDP ratio 2000s	WDI [2021]	1.83	1.77
Credit to GDP 1980s relative to 2000s	WDI [2021]	1.03	1.10
Credit to GDP 1960s relative to 2000s	WDI [2021]	0.82	0.82

Non-targeted moments	**Source**	**Data**	**Model**
Establishment share, < 10 employees	US Census [2021]	0.70	0.54
Establishment share, $10 - 19$ employees	US Census [2021]	0.14	0.22
Establishment share, $20 - 99$ employees	US Census [2021]	0.13	0.22
Establishment share, > 100 employees	US Census [2021]	0.03	0.01
Employment share, < 10 employees	US Census [2021]	0.15	0.19
Employment share, $10 - 19$ employees	US Census [2021]	0.11	0.16
Employment share, $20 - 99$ employees	US Census [2021]	0.30	0.38
Employment share, > 100 employees	US Census [2021]	0.45	0.27
Capital-output ratio	BEA [2016]	2.28	2.26
Self-employment rate	OECD [2015]	0.07	0.05
Labor share 1980s	BLS [2020].	0.63	0.64
Labor share 1960s	BLS [2020].	0.64	0.71

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 labour force of 7% as reported by the OECD [2015].[11]

Finally, although our focus is on the cross-country analysis, our model also has time-series implications. Since the 1960s, the US labour share has been falling and credit-to-GDP ratios have risen, while the college premium has experienced a u-shaped evolution. Our model is able to replicate these facts. Increasing educational attainment reduces both labour share and the college premium, whereas the fall in the price of capital has a positive effect on the college premium. In addition, increased TFP and financial market development also

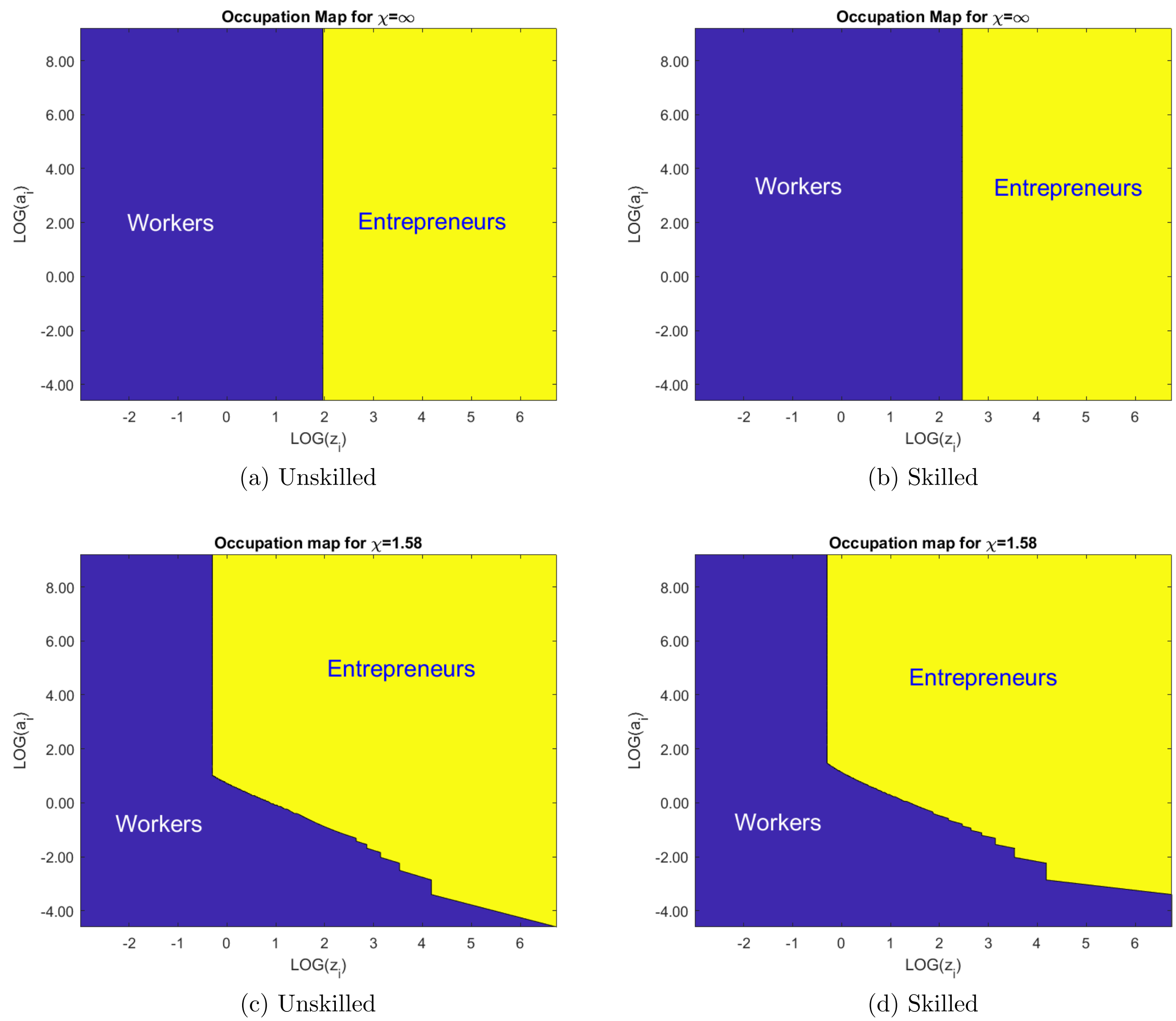
[11] The OECD statistic is also similar to the fraction of unincorporated self-employed over total employment in the US of 6%-7% as reported in Hipple [2010]. As the author points out, many data sources tend to count incorporated self-employed as employees, potentially also our source for average establishment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

contribute to a rise in the college premium over time.

3.1 Interaction between financial frictions and occupational choice

Given our calibration, we solve the model for economies with different levels of financial frictions. Figure 3 shows the occupational maps for the choice to become an entrepreneur

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



Notes: Panels (a) and (b) represent an economy without financial frictions ($\chi = \infty$), panels (c) and (d) represent an economy with moderate financial frictions ($\chi = 1.58$); these findings are the general-equilibrium results, and hence, prices change from one economy to another.

(light) or a worker (dark), depending on individuals' assets and managerial abilities. To illustrate the interaction between financial frictions and occupational choice, we consider two different economies: the baseline with fully developed financial markets ($\chi = \infty$), shown in panels (a) and (b); and one with moderate financial frictions, shown in panels (c) and (d) ($\chi = 1.58$; corresponding to a credit-to-GDP ratio of 0.74, close to Israel 's credit-to-GDP ratio for the 2000s). On the left-hand side, we show occupational maps for unskilled individuals, whereas those for skilled individuals are displayed on the right-hand side.

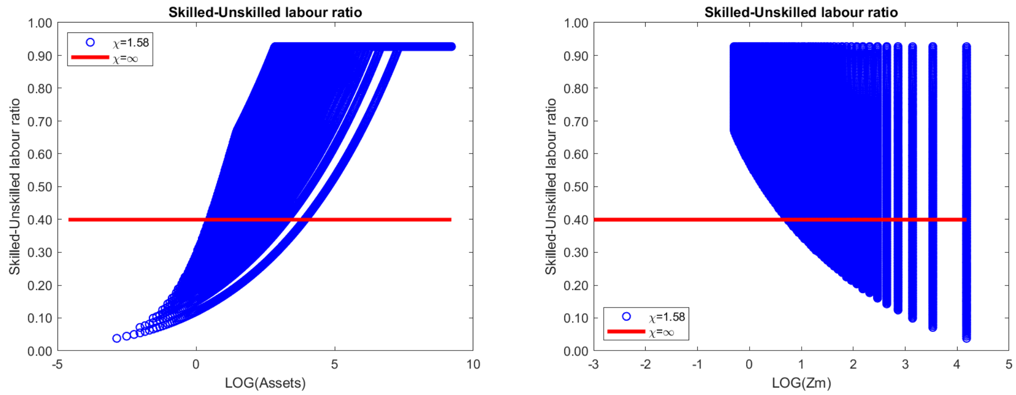
Without financial frictions, the choice to become an entrepreneur or a worker depends only on individuals' managerial abilities and not their assets, as indicated by the vertical line separating the two occupations in panels (a) and (b). Note this line lies just below the value of 2 for unskilled individuals but above the value of 2 for skilled individuals. Endowed with the same managerial ability, skilled and unskilled individuals obtain equal profits as entrepreneurs, but their outside options as workers are different. Unskilled individuals with lower managerial abilities become entrepreneurs because they would obtain lower wages as workers. The bottom panels show that even with moderate financial frictions, occupational choices depend on individuals' assets. In such an environment, a lack of assets leads individuals with high managerial abilities to become workers, while some wealthy individuals with low managerial abilities become entrepreneurs, generating misallocation of capital.

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 as a function of their assets (panel (a)) and managerial abilities (panel (b)). The continuous horizontal line in both panels represents the optimal skilled-to-unskilled-labour ratio in an environment with perfect capital markets ($\chi = \infty$). All entrepreneurs choose the same ratio, independently of their assets or managerial abilities. On the other hand, circles represent firms' optimal skilled-to-unskilled-labour ratios under moderate financial frictions ($\chi = 1.58$). As can be observed, substantial dispersion exists in the skilled-to-unskilled-labour ratio at the firm level, depending on entrepreneurs' assets and managerial abilities.

Similar to using the dispersion in firms' marginal product of capital as a measure of misal-

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



(a) (b)

Notes: Panel (a) shows skilled-unskilled-labour ratios as a function of entrepreneurs' assets; panel (b) shows the same ratios as a function of managerial ability, both for an economy with moderate financial frictions ($\chi = 1.58$); these findings are general-equilibrium results, and hence, prices change from one economy to another.

location as suggested by Hsieh and Klenow [2009], the dispersion in the skilled-to-unskilled-labour ratio can be interpreted as a measure of financial constraints. The more financially constrained entrepreneurs are, the higher their marginal product of capital and the lower their chosen capital stock relative to the optimal one. As a consequence of capital-skill complementarity, more financially constrained entrepreneurs also hire relatively fewer skilled workers. Misallocation of capital thus translates into misallocation of skills.[12]

Note that the skilled-to-unskilled-labour ratio for unconstrained firms is higher in an economy with financial frictions because, as we show in subsection 4.3, the college premium is lower in such an environment. As a result, unconstrained firms hire relatively more skilled workers. However, looking at Figure 4, whether the average firm's skilled-to-unskilled-labour ratio increases or decreases with financial market development is ambiguous. Given that the number of skilled individuals is fixed, any change in the aggregate skilled-to-unskilled-labour ratio can only arise due to asymmetric effects of financial frictions on occupational choices of skilled and unskilled individuals.

[12] Plots of firms' marginal product of capital for the different economies look similar. No dispersion occurs when financial markets are fully developed, and wide dispersion occurs when financial markets are restricted.

4 Cross-Country Analysis

For our main exercise, we vary financial frictions, TFP, and skilled labour across 129 countries ($j = 1, ...129$) using the share of the population above age 25 with a college degree from Barro and Lee [2013] and setting financial frictions (χ_j) and TFP (A_j) to match the observed values of domestic credit to GDP and GDP per capita relative to the US. The values for all countries are detailed in Tables A5 and A6 in the Appendix and are shown in Figure A3. We then perform a decomposition exercise to calculate the output gains of having perfect financial markets or improving educational attainment in isolation, and of carrying out both reforms at the same time. We perform robustness checks around the values of ρ and σ. We also analyze the effects of financial market development for wage inequality and entrepreneurship. Finally, we provide some empirical evidence for the existence of our model's firm-level interactions between capital and skilled labour.

4.1 Effects of financial development, educational attainment, and their interaction

Graph (a) in Figure 5 plots a histogram showing the increase in aggregate output if all countries were to fully liberalize their financial markets. The average output gain is close to 10%, varying between 0% and 30%. Graph (b) shows the effects of raising countries' educational attainment to US levels, leaving financial markets unchanged. Output gains are, on average, 9% but vary up to 50%.[13] This variability is due to initial differences in countries' educational attainment, financial market development, and TFP. In Graph (c) we simultaneously liberalize financial markets and raise educational attainment to US levels. Output gains are 24.7% on average. This is larger than the sum of separately carrying out each reform (19%), with an amplification of 30%. This amplification effect varies depending on countries' initial conditions in terms of educational attainment, TFP, and financial market development. Figure 6 shows its cross-country distribution. The cross-country average of the amplification effect is 33.7%, varying between 0% and 120%. Countries that gain less in terms of out-

[13]Increasing educational attainment can lead to skilled wages falling below unskilled wages. In those cases, we assume the excess skilled workers turn to unskilled jobs and that the two wages of skilled and unskilled individuals equate. This type of situation in which increasing educational attainment does not lead to output gains happens frequently in our model because the level of capital affects wages of skilled and unskilled individuals asymmetrically. Given our production function, the threshold after which more skilled workers do not raise production depends positively on TFP and the level of financial development, and for some countries, it already occurs when the share of the skilled population reaches 5%.

put when carrying out both reforms simultaneously are either those with high educational attainment, already developed financial markets, or very low TFP. To gain further insight into these amplification effects, we analyze the cross-country variability in output gains of financial market development and of improvements in educational attainment.

4.1.1 What determines output gains of financial development?

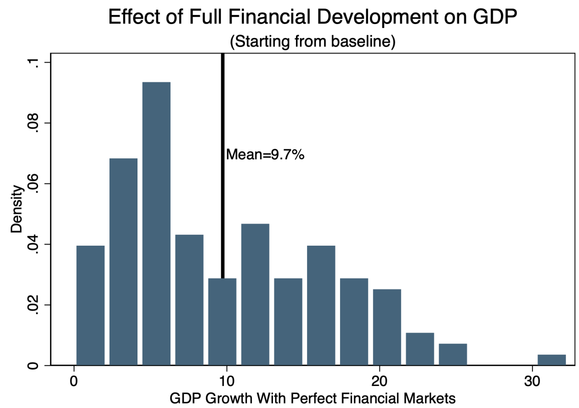
For the 129 countries in our sample, the output gains of developing financial markets vary between 0% and 30%. As Figure 7 shows, these gains are positively associated with countries' educational attainment and TFP, but negatively associated with the initial level of domestic credit. For countries with low educational attainment and low TFP, the output gains of liberalizing financial markets never surpass 10%. When we regress the estimated output gains on TFP, educational attainment, and the initial level of domestic credit, the coefficients for all three regressors are statistically significant.

To provide a better understanding of how each factor contributes to gains in aggregate output, we liberalize financial markets in the following three counterfactual scenarios. For each country, with its initial level of financial market development, we set (a) its educational attainment to the US level, (b) its TFP to the US level, and (c) both its education and TFP to the US level. Figure 8 shows the histograms of output gains under each scenario. With US levels of educational attainment or TFP, output gains from liberalizing financial markets would be, on average, 44% or 48% larger than in our initial experiment. When financial frictions are removed in economies similar to the US in terms of both educational attainment and TFP, output gains would more than double.

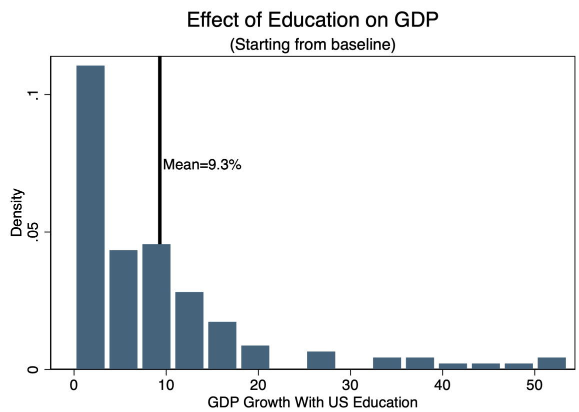
4.1.2 What determines output gains of educational attainment?

Instead of liberalizing financial markets, we now raise countries' educational attainment to US levels. Gains from improving educational attainment vary from 0% to 50%, and are negatively associated with countries' initial level of education and positively associated with TFP and financial market development (see Figure 9). For countries with low financial market development and low TFP, the output gains of raising educational attainment to US levels never surpass 10%. When we regress the predicted output gains on TFP, domestic credit, and the initial level of educational attainment, the coefficients for all three regressors are statistically significant.

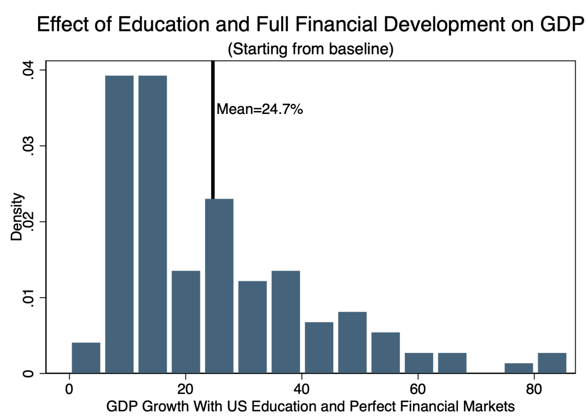
Figure 5: Effects of financial development, educational attainment, and their interactions



(a)



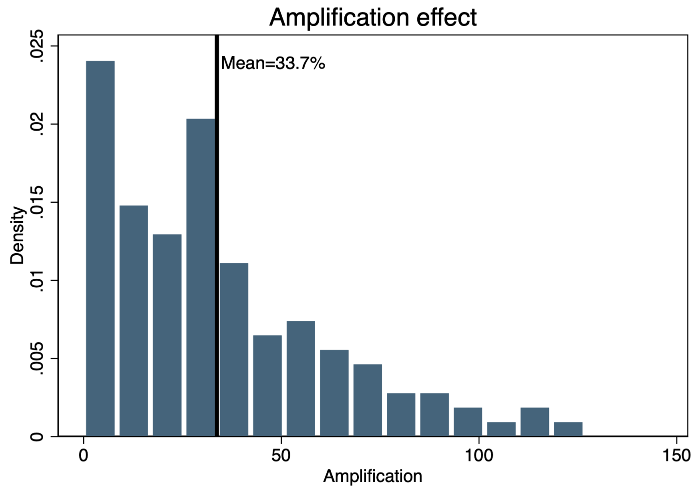
(b)



(c)

Notes: Model calculation. For each country, we calibrate χ_j and A_j to match domestic credit to GDP and GDP per capita PPP (from World Bank Development Indicators [2021] , average over 2000-2009), and we set θ_j equal to the share of college educated in the population above age 25 in 2005 from Barro and Lee [2013]. We then compute, for each country, three counterfactuals: (a) an economy with perfect financial markets ($\chi_j = \infty$), (b) an economy with US educational attainment $\tilde{\theta}_j = \theta_{US}$, and (c) an economy with perfect financial markets and the US educational attainment ($\chi_j = \infty$, $\tilde{\theta}_j = \theta_{US}$). For each of these economies, we calculate the percentage increase in GDP and plot the histogram for all 129 countries.

Figure 6: Amplification effect of simultaneously liberalizing financial markets and increasing education to the US level, all countries

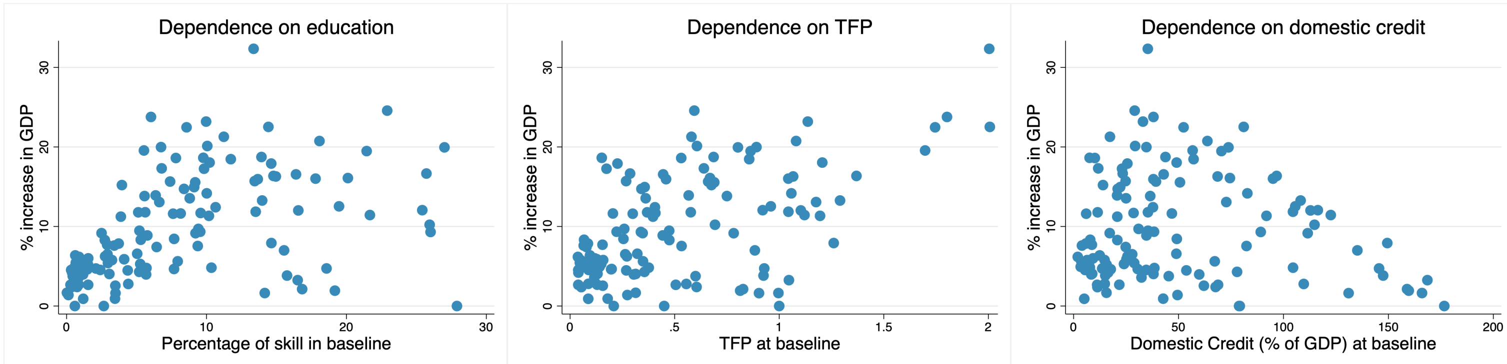


Notes: Model calculation. The amplification effect is calculated as the growth rate of output of implementing $\chi_j = \chi_{US}$ *and* $\theta_j = \theta_{US}$*, divided by the sum of the effects of implementing each one separately minus 1.*

Again, to highlight the different driving forces, we raise educational attainment to the US level in three counterfactual scenarios. For each country with its initial level of educational attainment, we set (a) its financial market development to the US level, (b) its TFP to the US level, and (c) both its financial market development and TFP to the US level. Figure 10 shows the histograms of output gains under each scenario. With US levels of financial market development or TFP, output gains from increasing educational attainment would be, on average, respectively 47% or 232% larger compared with the initial experiment. In economies similar to the US in terms of both financial market development and TFP, output gains would be four times as high.

Although we emphasize the interaction between financial development and educational attainment, other factors, that are captured by TFP in our study, also clearly matter. The effects of both financial market development and educational improvements are stronger in countries with higher TFP.

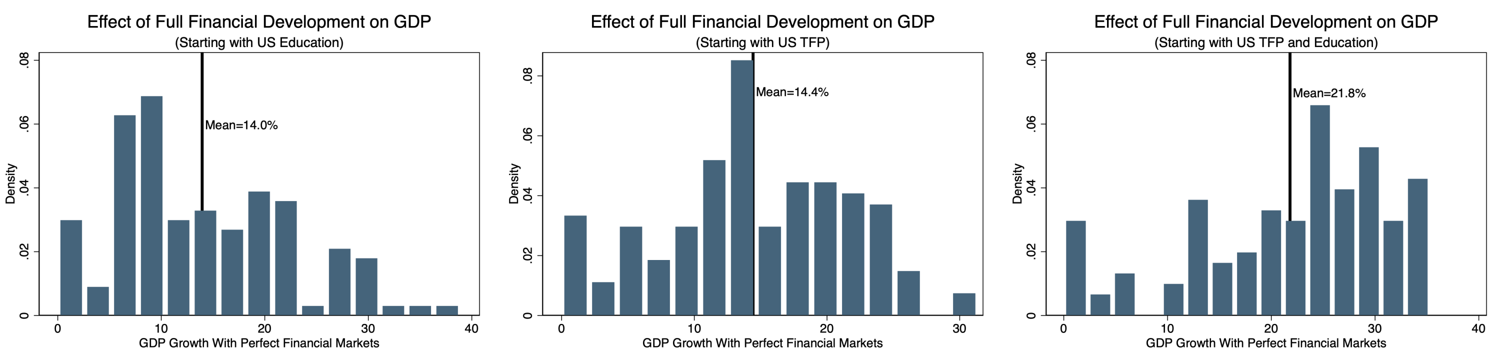
Figure 7: What determines the gains of financial development?



(a) (b) (c)

Notes: For each country, we plot GDP gains of perfect financial markets against the level of education, TFP, and initial domestic credit to GDP. The estimated multivariate regression result is $g_j = 6.01(16.55) + 0.62(15.27)\theta_j + 11.9(19.32)A_j - 0.15(-21.94)Credit_j$, *with t-statistics in parentheses and an R-squared of 0.869.*

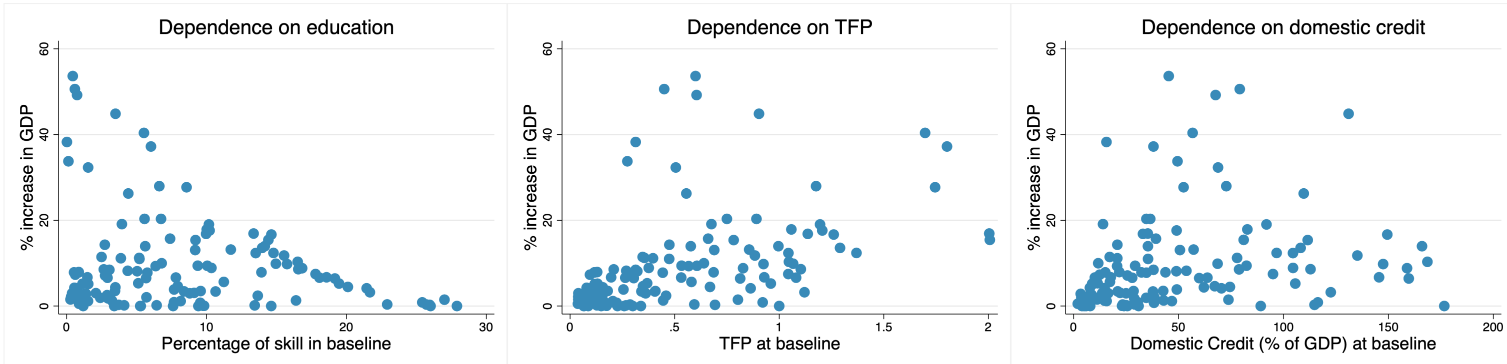
Figure 8: Counterfactual exercises: Financial development



(a) (b) (c)

Notes: Model calculation. For each country, we create counterfactual economies with (a) θ_{US}, *(b)* TFP_{US}, *and (c)* θ_{US} *and* TFP_{US}, *and compute the counterfactual GDP gains of perfect financial markets in each of these economies.*

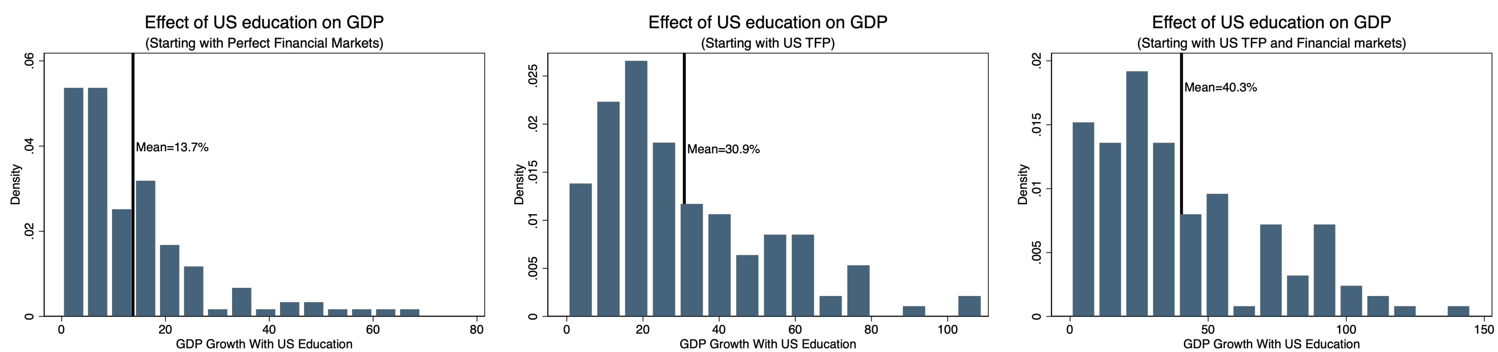
Figure 9: What determines the gains from educational improvement?



(a) (b) (c)

Notes: For each country, we plot GDP gains of perfect financial market against the initial level of education, TFP, and domestic credit to GDP. The estimated multivariate regression is $g_j = 6.26(5.62) - 1.22(-9.87)\theta_j + 17.24(9.16)A_j + 0.08(3.87)Credit_j$*, with the t-statistics in parentheses and an R-squared of 0.563.*

Figure 10: Counterfactual exercises: Educational improvement



(a) (b) (c)

Notes: Model calculation. For each country, we create counterfactual economies with (a) χ_{US}*, (b)* TFP_{US}*, and (c)* χ_{US} *and* TFP_{US}*, and compute the counterfactual GDP gains of raising educational attainment to the US level in each of these economies.*

4.2 Robustness to different elasticities of substitutions

Capital-skill complementarity in production is key for our results, and parameters σ and ρ play a crucial role. To check the robustness of our results, we re-run our model economy with different elasticities of substitution. Table 3 displays the average effects of financial market development and improvements in educational attainment, as well as the amplification effect from our baseline model next to those using alternative parameter values.

Typically, literature assigns values to ρ and σ of -0.495 and 0.401, respectively. These values come from estimations by Krusell *et al.* [2000], who propose an aggregate production function that includes private and public capital and that distinguishes between capital equipment that is complementary to skills and structures that are not. In our model, on the other hand, technology is defined at the firm level, and thus, capital refers to private capital only, and we also abstain from distinguishing between equipment and structures. The second column of Table 3 shows results using these alternative parameter values. Compared with our baseline model, the effects of financial market development and improvements in educational attainment are both quantitatively stronger, but the amplification effect of 27% is similar to ours.

Table 3: Sensitivity of results to elasticity of substitution

	Baseline model	Krusell et al [2000]	Fonseca and Van Doornik* [2022]	Cobb-Douglas Technology*
Effects of financial development				
129 different countries (χ_j, θ_j, A_j)	9.7%	12.2%	7.1%	43.7%
129 countries, with US education (χ_j, θ_{US}, A_j)	14.0%	17.7%	10.6%	32.3%
129 countries with US TFP (χ_j, θ_j, A_{US})	14.4%	11.0%	8.9%	40.6%
129 countries with US TFP & education (χ_j, θ_{US}, A_{US})	21.8%	17.2%	16.1%	31.8%
Effects of educational improvement				
129 different countries (χ_j, θ_j, A_j)	9.3%	19.8%	8.7%	39.7%
129 countries with US financial markets (θ_j, χ_{US}, A_j)	13.7%	25.7%	12.1%	27.1%
129 countries with US TFP (θ_j, χ_j, A_{US})	30.9%	43.8%	27.1%	36.6%
129 countries with US TFP & financ. mkts. (θ_j, χ_{US}, A_{US})	40.3%	53.1%	35.9%	27.1%
Sum of the effects of both reforms	19.0%	32.0%	15.7%	83.5%
Both reforms simultaneously	24.7%	40.7%	20.1%	87.1%
Amplification effect	29.7%	27.1%	27.8%	4.3%
Values for $\{\sigma, \rho\}$	$\{0.6, -0.11\}$	$\{0.40, -0.50\}$	$\{0.69, -0.23\}$	$\{0, 0\}$

*Note: *122 countries in the Fonseca and Van Doornik (2022) case and 120 countries in the Cobb-Douglas case; we dropped 7 and 9 countries respectively because were not able to achieve equilibrium for the particular parameter sets.*

Closer to our model is the model presented in Fonseca and Van Doornik [2022], where technology is defined at the firm level and firm capital encompasses both equipment and structures. In the third column, we present results using the parameter values estimated by these authors using data for Brazil of 0.69 and -0.23 for σ and ρ, respectively. Given that their numbers for σ and ρ are close to ours, these results are fairly similar to those from our baseline model. The effects of the isolated reforms are somewhat smaller than in our baseline model, whereas the amplification effect is 28%.[14]

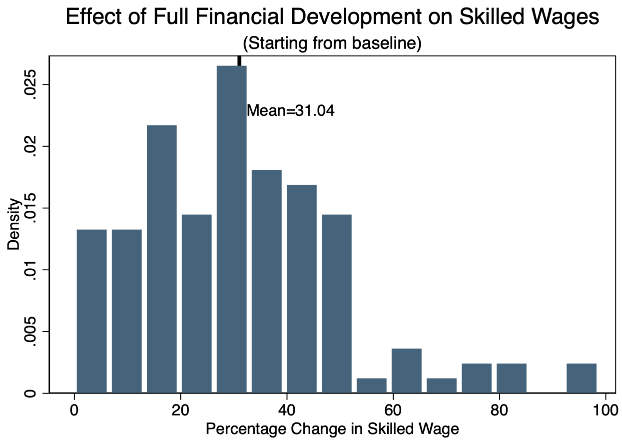
Finally, to highlight the importance of capital-skill complementarity for our results, we re-run our model assuming technology is characterized by a Cobb-Douglas production function. As shown in the last column of Table 3, in this case, the effects of financial development and educational improvement are four to five times larger than in our baseline model. More importantly, the magnitude of these effects changes very little when countries' TFP, educational attainment, or financial development change. Without capital-skill complementarity, the average amplification effect of carrying out both reforms simultaneously is only 4.3% compared with 30% in our baseline model.

4.3 Effects on wage inequality and firm productivity

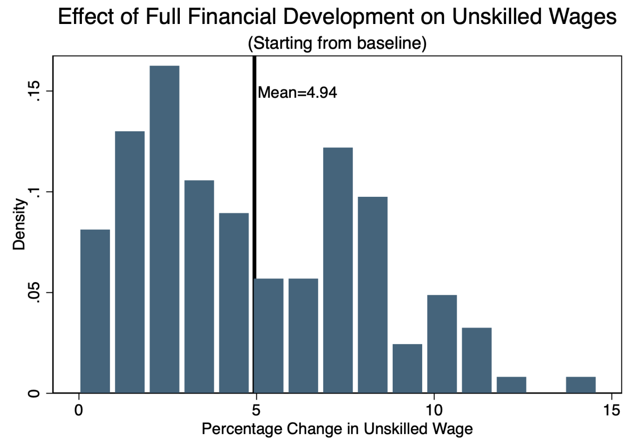
Capital-skill complementarity implies a clear link between the use of capital in production and wages of skilled workers. Hence, in our model, we expect financial development that alters firms' capital intensities to have distinct effects on wages of skilled and unskilled workers, ultimately affecting wage inequality. For our sample of 129 countries, Figure 11 displays the histograms for the percentage changes in skilled and unskilled wages as financial markets develop. On average, skilled wages increase by 31%, ranging from no effect in some countries to almost doubling skilled wages in others. Unskilled wages, on the other hand, increase by only 4.9% on average and at most by 15%. Financial development hence increases both skilled and unskilled wages, but the effect is much larger for skilled wages. This observation is in line with cross-country regressions showing a positive and significant relationship between domestic credit and college premia (see Table A2 in the Appendix). How much wage inequality increases depends on a country's initial level of educational attainment. We observe stronger increases when financial development is carried out in countries where few individuals hold a college degree.

[14] Other estimates for these parameters are hard to obtain. One of the few exceptions is Polgreen and Silos [2008], who use alternative time-series data for the price of capital equipment, and the model in Krusell *et al.* [2000] to reestimate values of ρ and σ between -0.567 and 0.010 and 0.392 and 0.917, respectively.

Figure 11: Effects of removing financial frictions on wage inequality



(a) Skilled

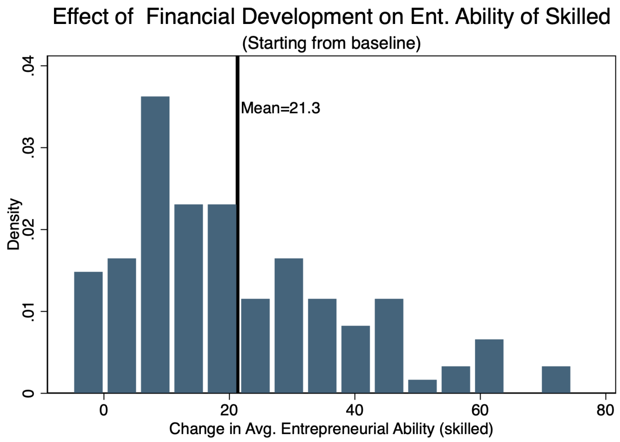


(b) Unskilled

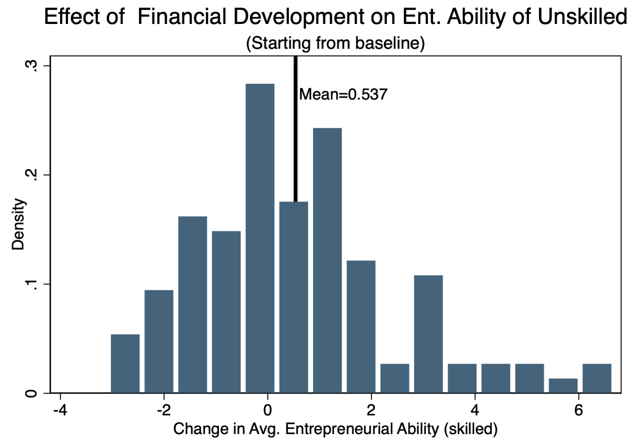
Notes: Based on model simulations. Both graphs consider a situation in which financial markets develop to $\chi_j = \infty$ *for each country. The left-hand graph displays the effect on skilled wages and the right-hand graph, on unskilled wages.*

In our model, removing financial frictions also has effects on the intensive and extensive margins of entrepreneurship. Regarding the latter, financial development helps detach the choice to become an entrepreneur from individuals' wealth. It also allows existing entrepreneurs to hire the optimal amount of capital and to grow to their optimal size. Within the framework of our model, we predict that financial development improves average managerial ability. Figure 12 displays histograms for the change in average entrepreneurial ability among skilled and unskilled entrepreneurs as financial markets develop. As financial development improves, so does the average managerial ability of skilled entrepreneurs. In contrast the average ability of unskilled entrepreneurs falls – a direct outcome of the increase in wage inequality. The result of higher managerial ability among skilled entrepreneurs is in line with suggestive evidence regarding a positive cross-country relationship between financial market development as measured by credit-to-GDP-ratios and the selectivity of higher-educated individuals running their own business. For 33 countries from our sample, we have data on entrepreneurs' cognitive skills and their education from the OECD's PIAAC (Program for International Assessment of Adult Competencies) survey [2016]. For these countries, we consider the population of individuals ages 16-65 with higher education (post-secondary or more), and we calculate the percentage difference between numerical skills of self-employed individuals and numerical skills of the entire population. In Figure A2 in the Appendix, we plot these percentage differences against countries' credit-to-GDP ratios. The correlation between both variables is small but positive (0.19), indicating that in countries with higher credit-to-GDP

Figure 12: Effects on entrepreneurial ability



(a) Skilled



(b) Unskilled

Notes: Based on model simulations. Both graphs consider a situation in which financial markets develop to $\chi_j = \infty$ *for each country. The left-hand graph displays the effect on average ability of a skilled entrepreneur, and the right-hand graph, on the average skill of an unskilled entrepreneur.*

ratios, the higher-educated individuals who become entrepreneurs are a positively selected group.

4.4 Firm-level interactions in model and data

Our model also has predictions for the relationship between output, human capital, and access to finance at the firm level. It generates a positive relation between firm size in terms of assets and the share of educated workers, which is weaker in countries with more developed financial markets. To compare these predictions with those observed in the data, we turn to the World Bank's Enterprise Survey [2006] , and we regress the share of educated workers (with 10 years of education or more) within a firm 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 firms' assets and the respective country's domestic-credit-to-GDP ratio. Table 4 shows the results from these regressions.

We find a positive and significant relationship between the share of educated workers within a firm and a firm's level of assets. The positive and significant coefficient on firms' assets, however, is smaller in countries with higher domestic-credit-to-GDP ratios. From the minimum (7.6%) to the maximum (136%) value of domestic credit to GDP, the slope coefficient varies between 3.72 (4.11) and 1.15 (-0.52) when considering the specification with (without)

Table 4: Firm-level regressions: model and data

	Data		Model
Log of firm's assets	4.380***	3.872***	2.121***
	[2.80, 5.96]	[2.54, 5.20]	[2.117, 2.124]
Log of firm's assets × domestic credit/GDP	-0.036*	-0.020**	-0.0045***
	[-0.073, 0.0010]	[-0.038,- 0.002]	[-0.0045, -0.0044]
Country dummies	X	X	X
Industry dummies		X	
Observations	10,369	10,359	4,183,195
R-squared	0.304	0.379	0.745

*Notes: Data from World Bank Enterprise Surveys [2006]. T-statistics are shown in brackets.*** indicates significance at the 1% level, ** indicates significance at the 5% level, and * indicates significance at the 10% level. In both regressions standard errors are clustered at the country level. Dependent variable is the % of workers with >10 years education. Using simulated data, each firm is weighted by its mass; see Table A1 for the summary statistics*

industry dummies. This finding indicates that, particularly in countries with less developed financial markets, firms with more assets employ a higher fraction of educated workers. We reproduce this regression in the model and estimate a coefficient of 2.12 and an interaction coefficient of -0.005, implying a slope coefficient between 2.09 and 1.51. This finding provides suggestive evidence that our analysis may reflect how access to finance affects firms' decisions to hire skilled individuals.

5 Conclusion

Capital-skill complementarity in production implies non-trivial interactions between firms' availability of human and physical capital. This result has important implications for economic development because gains from financial market development depend on countries' educational attainment. Our analysis shows these gains are very small when educational attainment and TFP are low. Additionally, we find substantial synergies of implementing educational and financial reforms jointly. However, our analysis is positive rather than normative, and hence, our results do not suggest one reform is preferable to the other. The ability to make such statements requires precise cost estimates including the time needed to implement each reform. We leave this type of analysis for future work.

Our results also indicate financial development is an important driver of wage inequality, raising wages of skilled workers, on average, around five times more than wages of unskilled workers. This finding presents two interesting questions. First, the macroeconomics literature has typically linked rising wage inequality to the complementarity between technology and skilled labour; see for instance, Acemoglu [1998]. However, depending on the estimation procedure and controls used, previous studies might have attributed increases in wage inequality to skill-biased technological change instead of financial market development.

Second, while we take educational attainment and financial frictions as given throughout our paper, the fact that financial frictions are an important driver behind wage inequality implies that the development of financial markets could directly affect individuals' choices to acquire an education. Hence, the demand-side channel that we studied could have implications for the supply side. The strength of such a mechanism would depend on the importance of how responsive educational attainment is to changes in skilled and unskilled wages. We view this hypothesis as a potentially interesting area for future research.

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

COMPANION APPENDIX

The Economic Journal

Lian Allub, Pedro Gomes, and Zoë Kuehn

Appendix A: Additional results

- Section A.1 Deriving the entrepreneur's optimal decisions
- Table A1 Summary statistics
- Table A2 Regression of GDP per capita (relative to US) on domestic credit and educational attainment
- Table A3 Implications of regression results with quadratic terms
- Table A4 Cross-country regression: College Premium
- Table A5 Sample of countries
- Table A6 Sample of countries continued
- Figure A1 College premium over time in data and model
- Figure A2 Selectivity of high-skilled entrepreneurs and financial frictions
- Figure A3 Cross-country, data and model

A Additional results

A.1 Deriving the entrepreneur's optimal decisions

The entrepreneur solves the following maximization problem:

$$\max_{\{l_i,h_i,k_i\}} \pi(z_i,a_i) = y_i - w^u l_i - w^s h_i - rk_i,$$

subject to the technology

$$y_i(l_i,h_i,k_i) = Az_i^{(1-\gamma)}[\mu l_i^\sigma + (1-\mu)[\lambda(qk_i)^\rho + (1-\lambda)h_i^\rho]^{\frac{\sigma}{\rho}}]^{\frac{\gamma}{\sigma}}$$

and the following collateral constraint:

$$k_i \leq \chi a_i.$$

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

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

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

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

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

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

and (A.1) and (A.3) provide us with the optimal ratio of capital-to-skilled-labour:

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

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

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

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

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

A.2 Cross-Country Regression

Table A1: Summary statistics

	Mean	Std	Min	Max	N	Source
Used in Table A.2. and Figure 1						
GDP per capita (rel. US, in %)	36.5	39.5	1.5	196.5	129	WDI [2021]
Credit-to-GDP ratio (in %)	51.0	44.8	2.0	182.5	129	WDI [2021]
Share of tertiary educated among population above 25 (in %)	8.2	7.0	0.02	27.8	129	Barro and Lee [2013]
Used in Table A.4						
College premium	9.9	3.3	1.6	17.5	102	Montenegro and Patrinos [2014]
Credit-to-GDP ratio	53.3	45.9	2.0	182.5	102	WDI [2021]
Share of tertiary educated among population above 25 (in %)	8.6	7.2	0.02	27.8	102	Barro and Lee [2013]
Used in Table 4						
% workers ($\geq$ 10 years of education)	47.4	33.5	0	100	10,359	World Bank Enterprise Survey [2006]
Log of firm's assets	10.5	4.3	-1.0	28.2	10,359	World Bank Enterprise Survey [2006]
Credit-to-GDP ratio (in %)	46.2	26.8	7.6	136.4	10,359	WDI [2021]

Table A2: Regression of GDP per capita (relative to US) on domestic credit and educational attainment

Domestic credit to GDP				
Linear	0.364***	[0.218,0.511]	0.706***	[0.297,1.116]
Quadratic			-0.004***	[-0.007-0.001]
% of tertiary educated				
Linear	1.786***	[0.854, 2.719]	4.825***	[2.447,7.203]
Quadratic			-0.213***	[-0.314, -0.112]
Domestic credit × % tertiary			0.0281**	[0.006,0.050]
Observation	129		129	
R-squared	0.428		0.523	

*Notes: The 95% confidence intervals are shown in brackets.*** significance at the 1% level, ** significance at the 5% level, and * significance at the 10% level. Sources: GDP per capita PPP and domestic credit-to-GDP from World Bank Development Indicators [2021]; average 2000-2009; educational attainment from Barro and Lee [2013] for 2005; see Table A1 for the summary statistics and Table A3 for an interpretation.*

Table A3: Implications of regression results with quadratic terms

		Marginal increase in GDP per capita upon increase of 1 percentage point in domestic credit-to-GDP for different shares of tertiary educational attainment
Percentile	% tertiary	Marginal effect
25th	2.66%	0.343
50th	6.44%	0.449
75th	13.37%	0.643

Notes: We evaluate the effect on GDP of an increase in domestic credit-to-GDP from 51% to 52%, for different share of tertiary educated, using the coefficients in the second column of Table A.2.

Table A4: Cross-country regressions of college premia on domestic credit and share or tertiary educated.

	Domestic credit-to-GDP	% of tertiary educated	Obs. (R^2)
College premium (logs)	0.003** [0.0007, 0.005]	-0.014** [-0.028,-0.0005]	102 (0.07)

*Notes: The 95% confidence intervals are shown in brackets.*** significance at the 1% level, ** significance at the 5% level, and * significance at the 10% level. Sources: Domestic credit-to-GDP from World Bank Development Indicators [2021]; average 2000-2009; educational attainment from Barro and Lee [2013] for 2005; college premium in logs taken from Montenegro and Patrinos [2014] (return to another year of schooling; data is average for 2000s whenever available; otherwise, closest data point); see Table A1 for the summary statistics.*

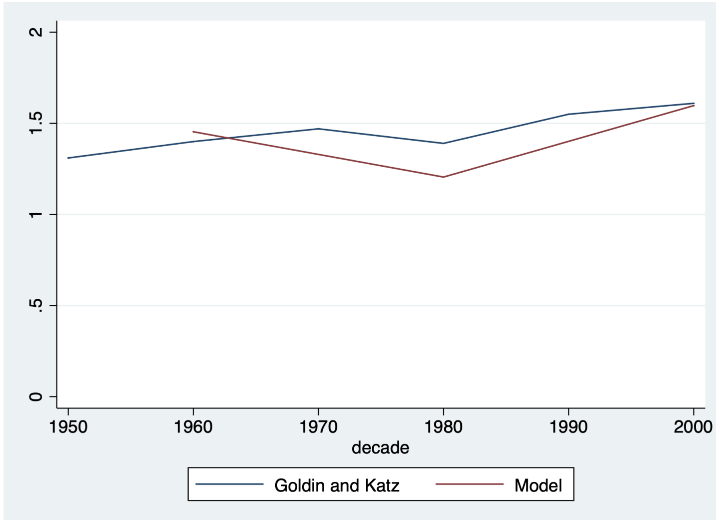
Table A5: Sample of countries

Country	χ_j	TFP_j	θ_j	Model Credit/GDP	Data Credit/GDP	Model GDP/USGDP	Data GDP/USGDP
Afghanistan	1.13	0.07	0.05	0.08	0.08	2.75	2.75
Albania	1.56	0.31	0.03	0.38	0.38	15.67	15.35
Algeria	1.11	0.37	0.05	0.11	0.11	18.53	18.53
Argentina	1.12	0.68	0.04	0.14	0.14	36.66	36.51
Armenia	1.22	0.27	0.13	0.25	0.25	13.39	13.38
Australia	2.15	0.96	0.19	1.06	1.06	78.88	79.20
Austria	1.95	1.20	0.10	0.92	0.92	93.48	93.59
Bahrain	1.38	1.21	0.10	0.49	0.49	89.05	89.09
Bangladesh	1.41	0.10	0.03	0.29	0.29	4.31	4.31
Barbados	2.54	0.60	0.01	0.68	0.67	29.58	29.60
Belgium	1.50	1.08	0.18	0.64	0.64	85.96	86.29
Belize	1.87	0.27	0.04	0.54	0.54	13.40	13.36
Benin	1.15	0.12	0.02	0.09	0.09	4.92	4.92
Bolivia	1.44	0.22	0.10	0.38	0.38	10.92	10.91
Botswana	1.23	0.47	0.03	0.21	0.21	24.26	23.80
Brazil	1.38	0.44	0.06	0.35	0.35	24.15	23.78
Brunei Darussalam	1.26	1.80	0.06	0.38	0.38	131.52	131.85
Bulgaria	1.33	0.46	0.14	0.38	0.38	26.40	26.31
Burundi	1.46	0.04	0.004	0.16	0.16	1.55	1.55
Cambodia	1.26	0.09	0.01	0.12	0.12	3.77	3.87
Cameroon	1.15	0.13	0.01	0.09	0.09	5.55	5.55
Canada	2.25	0.92	0.25	1.16	1.17	78.10	78.32
Central African Republic	1.14	0.05	0.01	0.06	0.06	2.00	2.00
Chile	2.14	0.53	0.09	0.82	0.83	33.09	33.20
China	∞	0.21	0.03	0.79	1.14	10.48	10.17
Colombia	1.23	0.36	0.09	0.25	0.25	18.99	19.20
Democratic Republic of Congo	1.05	0.04	0.01	0.02	0.02	1.46	1.46
Congo	1.06	0.14	0.01	0.03	0.03	6.01	6.01
Costa Rica	1.36	0.45	0.16	0.43	0.43	25.84	25.77
Cote d' Ivoire	1.19	0.16	0.03	0.15	0.15	7.09	7.09
Croatia	1.48	0.69	0.09	0.51	0.51	42.88	42.73
Cyprus	∞	0.83	0.17	1.59	1.70	69.36	69.35
Czech Republic	1.29	0.89	0.07	0.35	0.35	55.91	56.11
Denmark	36.19	1.05	0.17	1.69	1.60	95.97	96.02
Dominican Republic	1.22	0.40	0.04	0.21	0.21	19.73	19.68
Ecuador	1.20	0.34	0.08	0.21	0.21	17.37	17.40
Egypt	1.69	0.32	0.05	0.49	0.49	16.44	16.20
El Salvador	1.65	0.26	0.08	0.49	0.49	12.75	13.00
Estonia	1.68	0.67	0.20	0.74	0.75	46.01	46.03
Eswatini	1.49	0.31	0.0002	0.16	0.16	12.19	12.19
Fiji	1.97	0.35	0.08	0.67	0.67	19.29	19.35
Finland	1.59	1.07	0.15	0.69	0.69	82.84	83.17
France	1.85	1.06	0.10	0.83	0.83	78.27	78.33
Gabon	1.08	0.53	0.08	0.10	0.10	29.13	29.26
Gambia	1.14	0.10	0.01	0.08	0.08	4.21	4.21
Germany	2.22	1.04	0.14	1.05	1.05	83.54	83.91
Ghana	1.20	0.13	0.02	0.14	0.14	5.81	5.81
Greece	1.58	0.86	0.21	0.70	0.70	64.85	64.58
Guatemala	1.34	0.27	0.03	0.26	0.26	12.90	12.90
Guyana	3.73	0.27	0.001	0.50	0.49	11.39	11.39
Haiti	1.31	0.08	0.01	0.15	0.15	3.21	3.21
Honduras	1.72	0.18	0.03	0.43	0.43	8.44	8.48
Hong-Kong	4.65	0.93	0.19	1.46	1.45	80.13	80.16
Hungary	1.35	0.69	0.14	0.44	0.44	44.08	43.94
Iceland	∞	1.00	0.14	1.66	1.74	86.88	86.86
India	1.55	0.13	0.06	0.38	0.38	6.02	6.00
Indonesia	1.36	0.26	0.03	0.28	0.28	12.58	12.56
Iran	1.36	0.41	0.11	0.38	0.38	22.33	22.25
Iraq	1.05	0.30	0.08	0.06	0.02	15.05	14.65
Ireland	2.37	1.12	0.22	1.23	1.22	101.72	101.74
Israel	1.58	0.80	0.27	0.74	0.74	60.16	60.09
Italy	1.73	1.18	0.07	0.73	0.73	82.93	83.30
Jamaica	1.20	0.36	0.09	0.22	0.22	18.50	18.47
Japan	∞	0.81	0.19	1.60	1.76	69.21	69.19
Jordan	2.68	0.36	0.05	0.78	0.78	19.06	19.04
Kenya	1.32	0.13	0.04	0.25	0.25	5.64	5.64
Korea	2.30	0.69	0.26	1.15	1.15	52.88	53.01
Kuwait	1.45	1.70	0.06	0.57	0.57	123.02	123.41
Kyrgyzstan	1.09	0.15	0.10	0.08	0.08	6.73	6.73
Laos	1.12	0.15	0.03	0.09	0.09	6.76	6.76
Lesotho	1.10	0.09	0.01	0.05	0.10	3.70	3.58
Liberia	1.07	0.07	0.03	0.04	0.04	2.64	2.64
Libya	1.09	0.64	0.07	0.12	0.12	36.44	35.94
Luxembourg	1.61	2.01	0.14	0.81	0.81	196.54	196.49
Macao	1.38	1.75	0.09	0.52	0.52	138.91	139.09
Malawi	1.16	0.04	0.003	0.05	0.05	1.51	1.51
Malaysia	22.51	0.56	0.04	1.10	1.14	33.56	33.54
Maldives	1.86	0.60	0.004	0.45	0.45	27.40	27.50
Mali	1.31	0.09	0.01	0.15	0.15	3.60	3.60
Malta	2.80	0.78	0.09	1.12	1.11	55.07	55.06
Mauritania	1.26	0.20	0.01	0.18	0.18	8.70	8.70
Mauritius	2.41	0.51	0.02	0.69	0.69	25.83	25.85
Mexico	1.13	0.58	0.11	0.17	0.17	33.59	33.47
Mongolia	1.25	0.23	0.15	0.26	0.26	10.98	10.95
Mozambique	1.33	0.04	0.003	0.11	0.11	1.54	1.54
Myanmar	1.09	0.09	0.04	0.06	0.06	3.54	3.54
Nepal	1.52	0.09	0.02	0.35	0.35	3.75	3.75
Netherlands	2.28	1.10	0.17	1.13	1.13	93.96	94.44
Nicaragua	1.24	0.17	0.10	0.23	0.23	8.08	8.06
Niger	1.14	0.05	0.01	0.06	0.06	1.83	1.82

Table A6: Sample of countries - continued

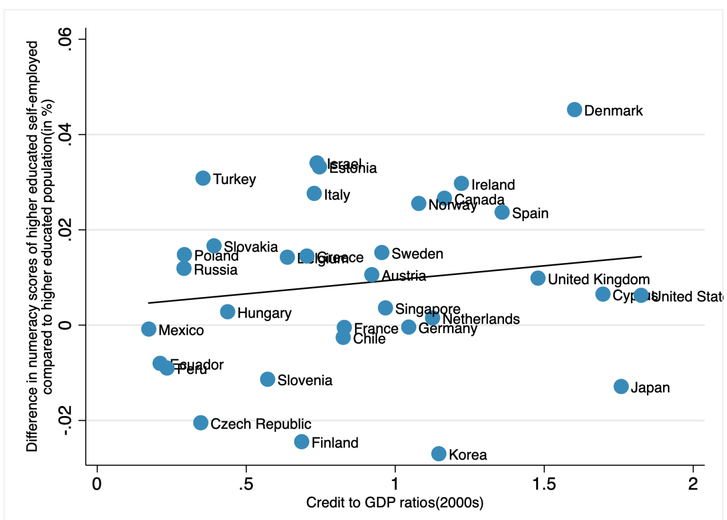
Country	χ_j	TFP_j	θ_j	Model Credit/GDP	Data Credit/GDP	Model GDP/USGDP	Data GDP/USGDP
Norway	2.18	1.29	0.14	1.08	1.08	112.01	112.41
Pakistan	1.28	0.15	0.05	0.24	0.24	6.79	6.80
Papua New Guinea	1.38	0.13	0.01	0.22	0.22	5.49	5.49
Paraguay	1.20	0.35	0.02	0.17	0.17	16.50	16.50
Peru	1.20	0.29	0.26	0.23	0.23	14.45	14.38
Philippines	1.34	0.20	0.08	0.31	0.31	9.43	9.44
Poland	1.24	0.61	0.10	0.29	0.29	35.40	36.03
Portugal	34.05	0.90	0.03	1.31	1.32	58.81	58.80
Qatar	1.21	2.00	0.13	0.35	0.35	177.39	177.95
Romania	1.19	0.57	0.06	0.21	0.21	31.85	31.38
Russia	1.19	0.59	0.23	0.29	0.29	37.06	36.97
Rwanda	1.30	0.05	0.004	0.11	0.11	2.14	2.14
Saudi Arabia	1.24	1.14	0.10	0.33	0.33	79.89	80.25
Senegal	1.30	0.12	0.01	0.15	0.15	4.84	4.85
Serbia	1.26	0.41	0.10	0.29	0.29	22.28	22.32
Sierra Leona	1.09	0.06	0.01	0.04	0.04	2.30	2.30
Singapore	1.93	1.37	0.15	0.97	0.97	120.33	120.80
Slovakia	1.37	0.66	0.07	0.39	0.39	39.05	38.89
Slovenia	1.50	0.86	0.12	0.57	0.57	58.43	58.32
South Africa	∞	0.45	0.01	0.79	1.36	21.26	21.31
Spain	4.40	0.88	0.16	1.35	1.36	70.92	70.60
Sri Lanka	1.32	0.26	0.09	0.31	0.31	13.07	13.13
Sudan	1.15	0.12	0.01	0.08	0.08	5.20	5.20
Sweden	1.94	1.04	0.18	0.95	0.95	85.37	85.19
Switzerland	4.69	1.26	0.15	1.49	1.49	114.83	115.21
Tajikistan	1.35	0.08	0.06	0.25	0.25	3.29	3.29
Tanzania	1.18	0.08	0.01	0.08	0.08	3.16	3.16
Thailand	8.60	0.38	0.10	1.05	1.07	22.01	22.50
Togo	1.31	0.06	0.02	0.16	0.16	2.31	2.31
Tonga	1.63	0.20	0.08	0.47	0.47	10.01	9.98
Trinidad and Tobago	1.34	0.75	0.06	0.37	0.36	44.48	44.58
Tunisia	1.96	0.30	0.06	0.60	0.60	15.98	16.01
Turkey	1.36	0.58	0.06	0.35	0.35	32.55	32.69
UK	5.91	0.92	0.16	1.48	1.48	78.23	78.38
US	∞	1	0.28	1.77	1.83	100	100
Ukraine	2.19	0.34	0.26	0.89	0.90	19.57	19.54
Uruguay	1.40	0.47	0.05	0.35	0.36	25.73	25.76
Vietnam	2.51	0.16	0.03	0.62	0.62	7.25	7.25
Zimbabwe	1.57	0.12	0.01	0.32	0.32	4.83	4.83

Figure A1: College premium over time in data and model



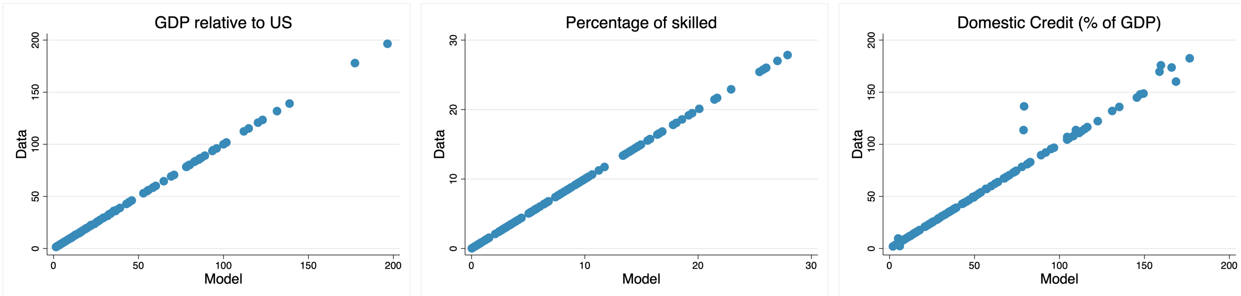
Notes: Data on college premium from Goldin and Katz [2009].

Figure A2: Selectivity of high-skilled entrepreneurs and financial frictions



Sources: Domestic credit-to-GDP from World Bank Development Indicators [2021]; average 2000-2009; cognitive skills from OECD's PIAAC survey [2016].

Figure A3: Cross-country, data and model



Notes: Comparison between model and data, for 129 countries; data for GDP and domestic credit from World Bank Development Indicators [2021] average 2000-2009; for educational attainment from Barro and Lee [2013] for 2005.