Human Capital and Financial Development*

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Abstract

We study an economy with capital-skill complementarities, an endogenous human capital and occupational choice decision and firm-level financing constraints. We ask: to what extent do financial frictions reduce output per worker across countries? In our economy, firm-level frictions depress physical capital accumulation and, in equilibrium, also reduce the acquisition of human capital, thus amplifying the decline in output per worker. We estimate the model using repeated cross-sections of individual workers' educational attainment, labor earnings and occupational choice, both for U.S. time-series, as well as for a cross-section of countries. We find that financial frictions have much larger effects on output per worker in our economy than they do in economies with a fixed supply of human capital.

Keywords: Human Capital, Financial Constraints, Economic Development.

JEL classifications: E21, E30.

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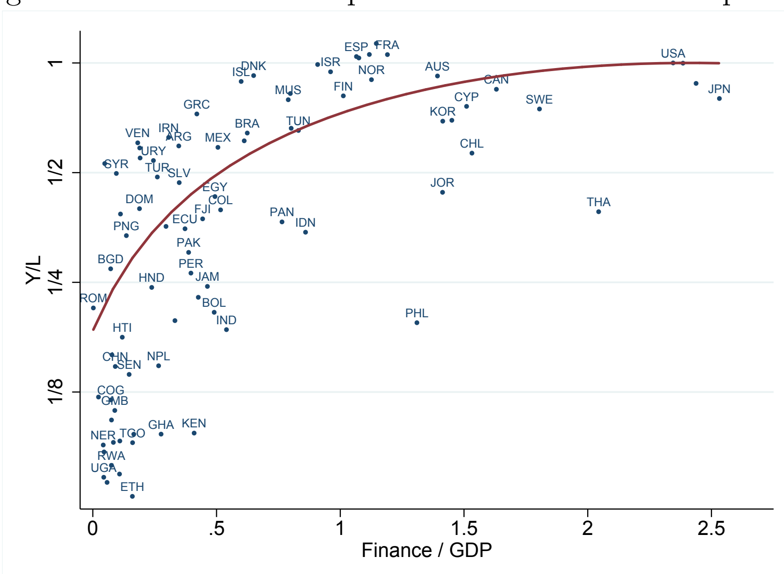
1 Introduction

What is the role of financial development in spurring economic development? We revisit this question using a model in which firm-level financial frictions not only depress physical capital accumulation, but also workers' human capital accumulation decision. In our economy human and physical capital are complements: a low level of financial development reduces physical capital, as well as the returns to human capital investments, thus amplifying the decline in output per worker.

Our work is motivated by the strong correlation between financial and economic development shown in Figure 1, where we plot output per worker across countries against a measure of external credit to GDP. Although this relationship does not indicate the direction of causality, it does raise the question of how important finance is in accounting for economic development.

Figure 1: Economic Development vs. Financial Development



Any theory capable of reproducing the relationship in Figure 1 must also be consistent with the observation that the capital-output ratio does not differ that much across countries. As Figure 2 shows, going from countries with a high level of financial development to those with no finance reduces the capital output ratio by a factor of 2.5. Combined with a relatively low share of capital in the production function, this implies that most variation in output per worker in Figure 1 cannot be accounted for by differences in the capital-output ratio alone. Indeed, as Figure 3 shows, differences in residual Total Factor Productivity (TFP) must play an important role.

Figure 2: Capital-Output Ratio

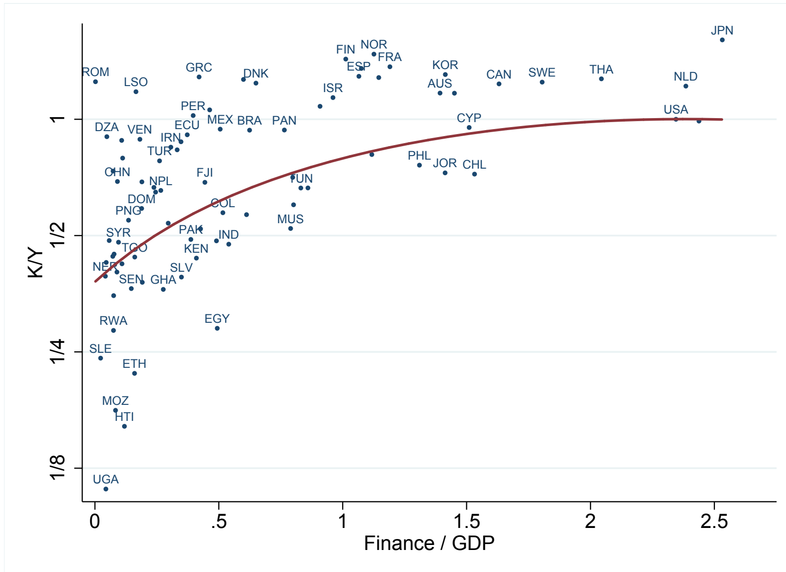
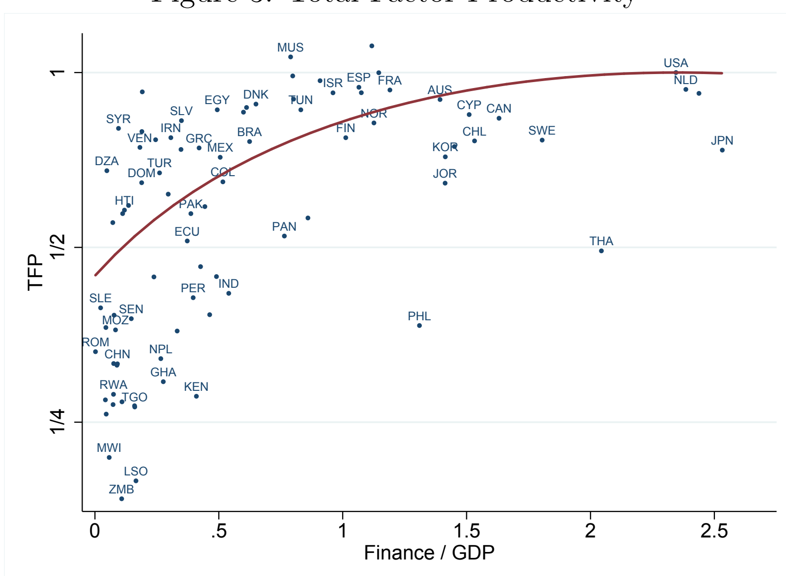


Figure 3: Total Factor Productivity



These sets of observations have motivated the finance and development literature to exploit mechanisms through which financial frictions distort measured productivity in an economy. These mechanisms include frictions that distort technology adoption choices, as well as misallocation of factors of production across establishments. In this paper we quantitatively pursue yet another mechanism. We study the interplay between firm-level financing constraints and worker human capital investment choices. We argue that the latter can be severely distorted by the presence of financial constraints in an economy that features capital-skill complementarities.

Related Work Our paper is related to a number of papers that study the role of human capital in economic development. Erosa et al. (2010) and Manuelli and Seshadri (2014) show that endogenizing human capital amplifies the effect of changes in TFP on output per worker. These researchers consider a one-sector model and therefore need to assume that goods are an important part of the human capital production function. In contrast, in our model goods are not an input in the production of human capital. Rather, an increase in the price of skilled labor raises schooling because of the extensive margin decision of which sector to enter. Castro and Sevcik (2016), as we do, study the role of debt constraints in distorting human capital accumulation choices. Unlike our paper, which focuses on the role of firm-level financing frictions in distorting worker's human capital choices, Castro and Sevcik (2016) focus on the entrepreneur's human capital accumulation decision. Another closely related paper is the work of Restuccia (2004) who studies the effect of capital taxes on worker's human capital accumulation decisions.

2 Model

We start by describing the steady state version of our model in which all prices and firm and worker distributions are time-invariant. We begin by discussing the workers' problem and then the problem of the firms.

2.1 Workers

Time is continuous and runs forever, $t \in [0, \infty)$. There are T overlapping generations of workers, born at discrete intervals of time, $t \in \{0, 1, 2, 3, \infty\}$, who each live for T periods. Newborn agents of a given generation differ along two dimensions: their ability z, as well as their discount rate ρ. We let $\omega = (z, \rho)$ index the worker's type. We assume that ω is drawn from some distribution Ω that we parameterize below.

At the beginning of their lives, agents choose how much schooling, S, to acquire. We assume a lower bound $S_{\min}$ on the schooling choice, reflecting compulsory schooling laws. An agent with ability z who spends S years in school acquires $h(z, S)$ units of human capital according to

$$h = zS^{\phi}, \tag{1}$$

where the parameter ϕ governs the elasticity of human capital with respect to schooling.

After the schooling period is over, an agent chooses which sector to join. There are three sectors in the economy: the (capital-intensive) skilled sector, s, the unskilled sector, u, or the home production sector, b. For simplicity, we assume that this sectoral choice is irreversible. The worker's human capital will continue to grow over time, due to learning-by-doing on the job, as a function of the sector the agent joins. An agent's income in each sector is a function of how much human capital she has acquired in school, as well as a idiosyncratic sector-specific productivity draw, $\varepsilon = (\varepsilon^s, \varepsilon^u, \varepsilon^b)$, where s indicates the skilled sector, u indicates the unskilled sector, and b indicates home production. Letting $g_i(x)$ denote the learning-by-doing component of one's human capital, a function of the agent's experience, $x = a - S$, a worker's income in each of the three sectors is equal to

$$y^s(h, x) = phg_s(x)\varepsilon^s$$

if the agent joins the skilled sector,

$$y^u(h, x) = wh^{\theta}g_u(x)\varepsilon^u$$

if the agent joins the unskilled sector, and

$$y^b(h, x) = B\varepsilon^b$$

if the agent engages in home production.

Here p and w represent the unit price of an efficiency unit of labor supplied to each sector, B represents the amount of output one produces at home, while $\theta \leq 1$ governs the extent to which human capital acquired in school raises one's efficiency units of capital in the unskilled sector. If $\theta = 1$, then a given amount of education raises human capital by the same amount in both the unskilled and skilled sector. If $\theta < 1$, then education is relatively more valuable in the skilled sector. Finally, we assume that the learning-by-doing component is given by

$$g_i(x) = 1 + (\alpha_{1i} - 1)(1 - \exp(-\alpha_{2i}x)),$$

where α_{1i} governs the long-run level of human capital accumulated on the job and α_{2i} determines the speed with which human capital converges to this level.

Let $V^i(\omega, S)$ denote the present value of labor earnings an agent will receive conditional on joining a particular sector i and receiving a unit draw of its idiosyncratic sectoral draw ε^i. That is,

$$V^s(\omega, S) = y^s(\omega, S)\exp(-\rho(\omega)S)\int_S^T \exp(-\rho(\omega)t)\left(\alpha_{1s} + (1-\alpha_{1s})\exp(-\alpha_{2s}(T-S))\right)\mathrm{d}t,$$

where $y^s(\omega, S) = pz(\omega)S^\phi$. Evaluating the integral, we have

$$V^s(\omega, S) = y^s(\omega, S)\exp(-\rho S)\left(\alpha_{1s}\frac{1-\exp(-\rho(T-S))}{T-S} + (1-\alpha_{1s})\frac{1-\exp(-(\rho+\alpha_{2s})(T-S))}{T-S}\right)$$

A similar expression holds for the other two sectors, except that income in each of these is proportional to $y^u(\omega, S) = w\left(z(\omega)S^\phi\right)^\theta$ and $y^b(\omega, S) = B$, respectively.

We assume that there is some randomness about what occupation a given individual is good at. We capture this notion by assuming that after the schooling period is over workers draw a vector of occupation-specific productivity from a Frechet distribution with shape parameter σ:

$$\left(\varepsilon^s, \varepsilon^u, \varepsilon^b\right) \sim G\left(\varepsilon^s, \varepsilon^u, \varepsilon^b\right) = \exp\left(-\left(\varepsilon^s\right)^{-\sigma} - \left(\varepsilon^u\right)^{-\sigma} - \left(\varepsilon^b\right)^{-\sigma}\right)$$

Notice that the sectoral draws ε^i are independent. The parameter σ governs the dispersion in these draws and thus determines the sensitivity of one's sectoral choice to relative sectoral prices. Taking expectations over these draws, an agent's expected life-time value conditional on having spent S years in school is

$$V(\omega, S) = \int \max\left[\varepsilon^s V^s(\omega, S), \varepsilon^u V^u(\omega, S), \varepsilon^b V^b(\omega, S)\right]\mathrm{d}G\left(\varepsilon^s, \varepsilon^u\right)$$

The assumption of Frechet draws considerably simplifies our calculations. In particular, the expected life-time present value of labor earnings is given by

$$V(\omega, S) = \left(V^s(\omega, S)^\sigma + V^u(\omega, S)^\sigma + V^b(\omega, S)^\sigma\right)^{\frac{1}{\sigma}}\Gamma\left(1-\frac{1}{\sigma}\right),$$

where Γ is the gamma function, the mean of the Frechet distribution. Moreover, the fraction of individuals with human capital who choose to enter each sector is given by

$$f^i(\omega, S) = \frac{V^i(\omega, S)^\sigma}{V^s(\omega, S)^\sigma + V^u(\omega, S)^\sigma + V^b(\omega)^\sigma}.$$

Finally, the distribution of sectoral draws, conditional on a worker joining a particular sector, is itself a Frechet random variable with shape parameter σ and a scale parameter

$\left(V^s\left(\omega,S\right)^\sigma + V^u\left(\omega,S\right)^\sigma + V^b(\omega,S)^\sigma\right)^{\frac{1}{\sigma}}$. These implications are very convenient in aggregating the decision rules of all agents and in computing equilibrium objects. In addition, the Frechet assumption implies that conditional on a given level of human capital, S, and initial conditions, ω, there are no sectoral wage premia: the average life-time earnings of agents entering each of the three sectors are the same in all of them. Differences in skill prices therefore only affect the fraction of agents with a given level of human capital who enter each sector, not their relative life-time earnings.

Consider next the optimal schooling choice. An agent of type ω solves

$$\max_{S \geq S_{\min}} V(\omega, S),$$

subject to the production function in (1). This gives, at an interior optimum:

$$\rho = \sum_{i \in \{s,u\}} f^i(h) \frac{1}{V^i(\omega,S)} \frac{\partial V^i(\omega,S)}{\partial S}$$

The agent thus trades off the opportunity cost of schooling, which delays entry into the labor market, and is more costly the higher the discount rate ρ is, against the benefit of schooling, given by the elasticity of a worker's life-time earnings with respect to schooling times the probability that the worker enters any individual sector. Note that the elasticity of life-time earnings with respect to schooling is equal to

$$\frac{1}{V^i(\omega,S)} \frac{\partial V^i(\omega,S)}{\partial S} = \frac{\xi_i}{S} - \frac{\alpha_{1i} e^{-\rho(\omega)(T-S)} + (1-\alpha_{1i}) e^{-(\rho(\omega)+\alpha_{2i})(T-S)}}{\alpha_{1i} \frac{1-e^{-\rho(\omega)(T-S)}}{\rho(\omega)} + (1-\alpha_{1i}) \frac{1-e^{-(\rho(\omega)+\alpha_{2i})(T-S)}}{\alpha_{2i}+\rho(\omega)}}, \tag{2}$$

where ξ_i represents the elasticity of an agent's efficiency units of skill supplied to sector i with respect to the schooling choice: $\xi_i = \phi$ in the skilled sector, $\xi_i = \phi\theta$ in the unskilled sector and zero in the home production sector. To gauge some intuition for the schooling choice, consider an economy with $\alpha_{1i} = 1$, that is, an economy without learning by doing. In that case, assuming an interior optimum, the schooling choice satisfies:

$$S(\omega) = \frac{f^s(\omega,S)\phi + f^u(\omega,S)\phi\theta}{\rho(\omega)\left(1 + \frac{\exp(-\rho(\omega)(T-S))}{1-\exp(-\rho(\omega)(T-S))}\right)}.$$

We can further simplify this expression by assuming no discounting, so that $\rho(\omega) \to 0$, in which case we have, at an interior optimum:

$$S(\omega) = \frac{f^s(\omega,S)\phi + f^u(\omega,S)\phi\theta}{1 + f^s(\omega,S)\phi + f^u(\omega,S)\phi\theta} T.$$

This says that the fraction of life-time spent in school is increasing in the elasticity ϕ that governs the extent to which an additional unit of schooling raises human capital, as well as the extent to which human capital is valuable in the unskilled sector, θ. Also notice that initial ability $z(\omega)$ only affects the schooling choice insofar as it raises the probability that agents end up choosing the sectors that disproportionately value human capital, $f^s(\omega, S)$ and $f^u(\omega, S)$. Low z agents have a higher probability of becoming non-employed and, since the home production sector does not require human capital, such agents accumulate less schooling. Agents with intermediate values of z have a relatively higher probability of choosing the unskilled sector and accumulate relatively more schooling. Finally, agents with the highest values of z are most likely to join the skilled sector which has the highest returns to education, and so they accumulate the most schooling.

2.2 Firms

We assume a non-convexity in the firm's choice of capital: firms can either operate a *modern* technology, which uses capital, or a *traditional* technology, which does not. We assume that the modern technology requires a minimum level of investment of $\underline{k}$ units of capital. The traditional technology produces output y using unskilled labor as its only factor:

$$y = Bl_u^{\eta},$$

where η governs the degree of returns to scale. The modern technology, in contrast, features capital-skill complementarity. For analytical convenience, here we assume that capital and skilled labor are combined in a Leontieff fashion to produce a skilled composite good, which is then combined with unskilled labor to produce output. We thus have

$$y = e\left(l_u^{\nu} \min\{k, \lambda l_s\}^{1-\nu}\right)^{\eta},$$

where ν determines the share of unskilled labor in production, and λ determines the ratio of capital to skilled labor in production, while e is a parameter that governs the relative efficiency of the modern sector. We assume that the parameter values are such that absent financial constraints firms would find it optimal to operate using the modern technology.

We assume that each firm can exit for exogenous reasons at a Poisson rate μ. The firm maximizes the PV of its life-time dividends, discounted at rate ρ_f:

$$\int_0^{\infty} e^{-(\rho_f+\mu)t} d_t \mathrm{d}t, \tag{3}$$

where d_t are the dividends the firm issues at each instant, subject to the budget constraint subject to

$$\mathrm{d}a_t = (\pi(a) + ra - d_t)\,\mathrm{d}t, \tag{4}$$

where r is the exogenously given return on financial wealth, and a is the firm's net worth, given by the sum of the firm's capital, k and financial wealth b. The firm's flow profits,

$$\pi = \max_{l_u, l_s, k} y - wl_u - pl_s - (r+\delta)k$$

are an increasing function of the firm's net worth, owing to a borrowing constraint that states that the firm's debt, $-b$, cannot exceed a fraction θ_f of the firm's physical capital:

$$b \geq -\theta_f k,$$

or alternatively, that the firm's physical capital cannot exceed a multiple of the firm's net worth:

$$k \leq \frac{1}{1-\theta_f} a. \tag{5}$$

For constrained firms for which the borrowing constraint (5) binds, an additional unit of net worth relaxes this constraint, and thus raises the firm's profits, so that $\pi'(a) > 0$.

We do not explicitly derive the solution to the firm's profit function and demand for capital, skilled and unskilled labor here, since these are quite involved. Suffices to say that the firm's profit function is initially flat and equal to

$$\pi(a) = \underline{\pi} = \left(\eta^{\frac{\eta}{1-\eta}} - \eta^{\frac{1}{1-\eta}}\right)\left(\frac{1}{w^{\eta}}\right)^{\frac{1}{1-\eta}},$$

for producers who do not have the minimum level of wealth, $\underline{a} = (1-\theta_f)\underline{k}$, necessary to operate in the modern sector.

Producers with wealth in an intermediate region enter the modern sector but are initially constrained and set $k = \frac{1}{1-\theta_f} a$, $l_s = \frac{1}{\lambda}\frac{1}{1-\theta_f} a$, etc. Finally, sufficiently wealthy producers have a sufficient amount of wealth to be able to afford the unconstrained amount of capital. Letting $a^* = (1-\theta_f)k^*$ denote the minimum amount of wealth at which firms can afford the unconstrained amount of capital, $k^*(r, w, p)$, the profit function is once again flat in the $a \geq a^*$ region.

Given this profit function, the firm's optimal dividend policy is straightforward: the firm issues zero dividends whenever its wealth is below a^*, and then pays out the unconstrained level of profits and annuity value of its wealth as dividends thereafter.

We assume that firms that exogenously exit are replaced with new firms that start out with zero wealth. Such firms thus initially enter the traditional sector and after they accumulate a sufficiently large stock of wealth, they switch to the modern sector.

3 Data

Here we document salient features of the schooling and occupational choices of workers in the U.S. between 1960 and 2000. We use the 5% sample of the U.S. census for years 1960 and 2000 from IPUMS. We restrict attention to US-born individuals between 18 and 64 years of wage who either work in the private sector or are non-employed. That is, we exclude individuals that are either self-employed or work for the government. We also exclude (*i*) individuals who are in school or who have educational attainment below grade 5, (*ii*) individuals with potential experience below one or above 40, and (*iii*) institutionalized individuals. We measure potential experience using age - 18 for those with less than 12 years of schooling education is below 12 and age - years of education - 6 for those with 12 or more years of experience. We weigh all statistics using the appropriate sample weights.

3.1 Schooling

Panel A of Table 1 reports moments of the distribution of years of education in the U.S. in 1960 and 2000. Note that educational attainment has increased from 10.9 to 12.9 years of schooling on average, with a more pronounced increase at the bottom of the distribution. The 10th percentile has increased from 8 to 11 years; the 25th percentile has increased from 8 to 12 years; while the 90th percentile has increased from 14 to 16 years of schooling.

3.2 Occupations

We next examine the distribution of individuals across occupations, and then contrast the level of schooling for individuals that join a given occupation.

We classify individuals into three occupations: skilled, unskilled, and non-employed. The latter group includes individuals who either report not working or whose annual labor income is below $1000 dollars.[1]

We classify the rest of the individuals who work as "skilled" or "unskilled" based on the occupation they report. For each 3-digit occupation we calculate the average number of years

[1] All dollar values have been deflated and are expressed in units of 2000 dollars.

	1960	2000
A. Years of education		
Mean	10.9	12.9
10^{th} percentile	8	11
25^{th} percentile	8	12
50^{th} percentile	11	12
75^{th} percentile	12	14
90^{th} percentile	14	16
B. Share of individuals by occupation		
Skilled	0.09	0.23
Unskilled	0.53	0.57
Non-employed	0.38	0.19
C. Mean years of education by occupation		
Skilled	13.5	14.6
Unskilled	10.5	12.5
Non-employed	10.7	12.3

Table 1: Schooling and Occupations

of schooling reported by individuals employed in that occupation by pooling data from 1960 and 2000.[2] We then classify an occupation as "skilled" if the average schooling levels in that occupation lie in the top third across all occupations. The corresponding cutoff is equal to 13.2 years of schooling. The bottom two-thirds of the occupations are then classified as "unskilled".

Panel B of Table 1 shows that there has been a substantial increase in the share of individuals who work in occupations we classify as skilled, from 9% in 1960 to 23% in 2000. The share of individuals employed in unskilled occupations has been roughly constant over time, 0.53 and 0.57, respectively. Finally, the fraction of non-employed individuals has fallen substantially, from 38% to 19%, largely due to the increase in women's labor force participation.

Panel C shows that educational attainment increased in all occupations between 1960 and 2000, but more so in the unskilled sector (from 10.5 to 12.5 years) than in the skilled

[2]To ensure consistency over time, we restrict attention to the `occ1990` occupational classification.

sector (from 13.5 to 14.6 years). Individuals in skilled occupations thus have, on average, approximately 2 to 3 more years of schooling than those who are in unskilled occupations or do not work.

3.3 Annual Labor Earnings

We next examine the extent to which labor earnings vary with schooling and across occupations. We do so by focusing on annual labor income measured in constant 2000 dollars.[3]

Panel A of Table 2 reports earnings by occupation, normalizing the earnings of unskilled workers in 1960 to unity. As is well-documented, the skill premium has increased from 1960 to 2000, from 1.64 to 1.77. This increase reflects a much larger increase in the average wage of those in the skilled occupations (36%) compared to those in unskilled occupations (26%).

Panel B of Table 2 reports the Mincerian returns to schooling in the two years, which we measure by computing the Mincerian returns. As is standard, we calculate these returns by regressing the logarithm of one's annual earnings against schooling and a quadratic polynomial in years of experience. Note that the Mincerian returns have increased dramatically in this time period, from 9% to 16%.

Finally, Panel C of Table 2 shows a substantial increase of earnings dispersion between 1960 and 2000. In particular, the coefficient of variation of annual labor earnings has increased from 0.62 to 0.73.

3.4 Earnings-experience profiles

We finally examine the relationship between earnings and (potential) experience in each period as well as for each occupation. Table 3 reports the average earnings across 5-year experience bins, normalizing the average earnings of those with 1 to 5 years experience to unity. We note that these earnings-experience profiles are nearly equally steep, both across occupations, as well as across years, with a life-time increase in average wages of about 70%.

4 Parameterization

We group parameters into two sets. We assign values to parameters in the first set based on evidence from existing studies. We calibrate the rest of the parameters to match the

[3]We winsorize the top 2.5% of observations in each year.

	1960	2000
A. Earnings by occupation		
Unskilled	1	1.26
Skilled	1.64	2.23
B. Returns to schooling		
Mincerian returns	0.09	0.16
C. Earnings dispersion		
Coefficient of variation	0.62	0.73

Table 2: Earnings by Schooling and Occupation

salient facts on educational attainment, occupational choices and skill premia discussed in the previous section.

Assigned Parameters. The left column of Table 5 reports these parameters. Agents are born at age 6 and live for $T = 60$ periods, thus retiring at age 65. The minimum number of years in school, $S_{\min}$, is set equal to 4 years in 1960 and 10 years in 2000, based on the evidence in Goldin and Katz (2008). We set the annual discount rate of the firm, ρ_f, equal to 0.04, the interest rate r equal to 0.04, and the exit rate equal to $\mu = 0.12$. We assume a 6% depreciation rate, a 2% aggregate productivity growth.

An important set of parameters are those that govern the technology with which firms operate. We set these parameters to reproduce the equilibrium in the year 2000 equal to $\nu = 0.51$, $\lambda = 6.53$. Finally, we assume that the productivity in the modern sector is $e = 1.46$ and that in the traditional sector equal to $B = 0.71$. We follow the literature in setting the parameter governing the degree of returns to scale equal to $\nu = 0.90$.

Calibrated Parameters. We choose all the other parameters by minimizing the distance between a number of moments in the data and in our model, for 1960 and 2000. In comparing the model to the data, we assume that the change in demand for skills, and thus skill prices happens in 1961 and that the 2000 data reflects the new steady state. We list the moments,

	Skilled		Unskilled	
	1960	2000	1960	2000
1-5 years	1.00	1.00	1.00	1.00
6-10 years	1.42	1.29	1.46	1.46
11-15 years	1.69	1.50	1.74	1.71
16-20 years	1.74	1.61	1.74	1.79
21-25 years	1.76	1.64	1.72	1.86
26-30 years	1.71	1.71	1.66	1.93

Table 3: Earnings-Experience Profiles

in both the data and in the model, for 1960 and 2000, in Table 4.

Notice that our model does an excellent job at matching the increase in education from 1960 to 2000 It also reproduces the increase in the share of individuals who join a skilled occupation from 0.12 (0.09 in the data) in 1960 to 0.20 (0.23 in the data) in 2000. The model also reproduces well the drop in the share of the non-employed, from 0.31 (0.38 in the data) in 1960 to 0.13 (0.19 in the data).

Also notice that the model reproduces well the relatively higher educational attainment of those joining the skilled sector. The average schooling of those in the skilled sector is equal to 13.7 in 1960 (13.5 in the data) and 14.7 in 2000 (14.6 in the data). As in the data, those in the unskilled sector have about 2-3 less years of schooling.

Consider next the model's implications for the skill premium: the average labor earnings of those employed in the two different sectors. Recall that the skill premium was equal to 1.64 in the data in 1960, a number which our model reproduces quite well – the skill premium in the model is equal to 1.54. As in the data, the skill premium increases in the model, reflecting a sharper increase in the average labor earnings of those in the skilled sector of about 25% (= 1.92/1.54) compared to those in the unskilled sector of about 17%. The corresponding numbers for the data are 37% and 26%, respectively.

Finally, notice that the model overstates the Mincerian returns to schooling, but does qualitatively account for the rise in these returns across time. In the model the Mincerian returns are equal to 0.15 in 1960 (0.09 in the data) and increase to 0.21 in 2000 (0.16 in the data). The model also accounts for the observed rise in wage dispersion, though we once again overstate the coefficient of variation of the labor earnings of different individuals.

Finally, our model matches the observed increase in the slopes of the earnings-experience profiles we observe in the data.

The right column of Table 5 lists the parameter values that allow our model to achieve this fit. The discount rate of workers is $\rho = 0.026$, the mean ability is $\mu_z = 0.19$, while the standard deviation of the log-normal ability draws is quite large, $\sigma_z = 0.79$. The Frechet shape parameter is $\sigma = 3.25$. The elasticity of human capital with respect to schooling is equal to $\phi = 0.85$. Human capital is half as valuable in the unskilled sector as it is in the skilled sector: $\theta = 0.52$.

The most important parameters are the skill prices. Accounting for the increase in skill premium in the U.S. requires an increase in the price of skilled labor from $p = 0.52$ in 1960 to $p = 0.77$ in 2000, thus an almost 50% increase. Recall, however, that average labor earnings have only increased by 25% in the model from 1960 to 2000. This lower increase reflects selection, as agents that are lower ability and would have otherwise joined the home production sector or the unskilled sector now enter the skilled sector. This decline in the average human capital of those entering in the skilled sector is striking especially in light of the increased number of schooling of agents joining that sector.

5 Quantitative Implications

We next study our model's implications for the effects of financial development on output per worker and skill prices. We consider two versions of our model, one without a non-convexity in the firm's choice of capital, and another one in which we set $\underline{k}$ equal to 80% of its unconstrained optimal value.

5.1 No Non-Convexity

Figures 4-6 illustrate the effect of tracing θ, the parameter governing the firm's ability to borrow, from 0 (no external finance) to 1 (no financial constraint). Figure 4 shows that output per worker falls by only about 5% as we go from $\theta = 1$ to $\theta = 0$ in an economy with an exogenous supply of human capital. In contrast, endogenizing the human capital choice doubles the drop in output per worker to 10%. Figure 5 shows that the price of skilled labor, p falls by about 20% in the absence of external finance, while that of unskilled labor falls by about 10%. This result is intuitive, since capital and skilled labor are more complementary. Figure 6 shows how the agents' occupational and human capital choices are shaped by the

Table 4: Moments

Moments Used in Calibration

	1960		**2000**	
	Data	Model	Data	Model
A. Years of education				
Mean	10.9	10.9	12.9	12.9
10th percentile	8	8	11	11
25th percentile	8	8	12	11
50th percentile	11	11	12	12
75th percentile	12	13	14	14
90th percentile	14	14	16	16
B. Share of individuals by occupation				
Skilled	0.09	0.12	0.23	0.20
Unskilled	0.53	0.57	0.57	0.66
Non-employed	0.38	0.31	0.19	0.13
C. Mean years of education by occupation				
Skilled	13.5	13.7	14.6	14.7
Unskilled	10.5	11.4	12.5	12.7
Non-employed	10.7	8.8	12.3	11.4
D. Earnings by occupation relative to 1960				
Unskilled	1	1	1.26	1.17
Skilled	1.64	1.54	2.23	1.92
E. Return to schooling and earning dispersion				
Mincerian returns	0.09	0.15	0.16	0.21
Coefficient of variation	0.62	0.83	0.73	0.90
F. Earnings-Experience Profiles				
1-5 years	1.00	1.00	1.00	1.00
6-10 years	1.47	1.31	1.56	1.34
11-15 years	1.73	1.50	1.75	1.55
16-20 years	1.75	1.63	1.88	1.69
21-25 years	1.70	1.71	1.88	1.78
26-30 years	1.63	1.77	1.87	1.84

Table 5: Parameters

Assigned			Calibrated		
T	60	Years to live	ρ	0.026	Discount rate workers
$S_{\min,1960}$	4	Minimum schooling 1960	μ_z	0.19	Mean ability
$S_{\min,2000}$	10	Minimum schooling 2000	σ_z	0.79	Standard deviation ability
ρ_f	0.04	Firm discount rate	σ	3.25	Shape parameter Frechet
r	0.04	Interest rate	α_{1s}	2.67	LBD, skilled sector
μ	0.12	Exit rate	α_{1u}	3.07	LBD, unskilled sector
δ	0.06	Depreciation rate	α_{2s}	0.067	LBD speed, skilled
g	0.02	Productivity growth	α_{2u}	0.122	LBD speed, unskilled
ν	0.51	Unskilled l share	ϕ	0.85	Human capital prod. fn elast.
λ	6.53	Skilled l/k ratio	θ	0.52	Elast. human capital, unskilled
e	1.46	Efficiency, modern	B	1.97	Home production
B	0.71	Efficiency, traditional	p_{1960}	0.52	Unit price, skilled labor, 1960
η	0.90	Returns to scale	p_{2000}	0.77	Unit price, skilled labor, 2000
			w_{2000}	1.25	Unit price, unskilled labor, 1960

presence of borrowing constraints. A lot fewer agents join the skilled sector (15% vs. 20% in the absence of constraints), the fraction of agents in the unskilled sector is essentially unchanged, while the fraction of those in home production increase by about 5 percentage points.

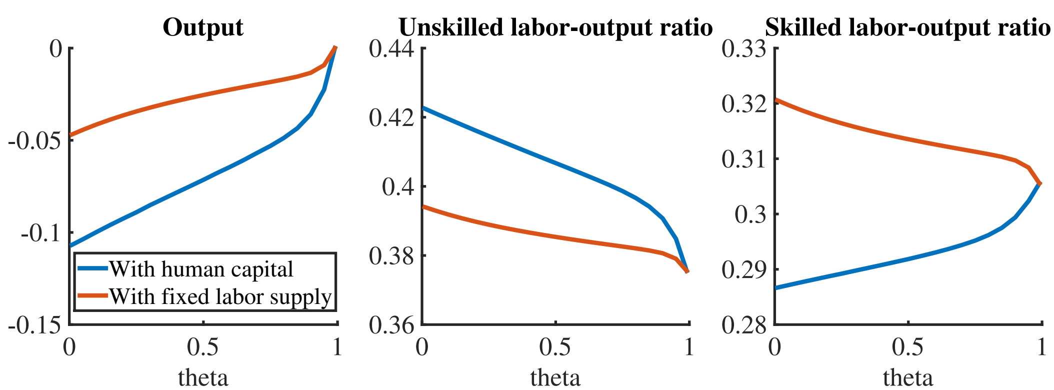


Figure 4: Output, effective labor supply in each sector divide by output

Figure 5: Price per-unit of human capital in each sector.

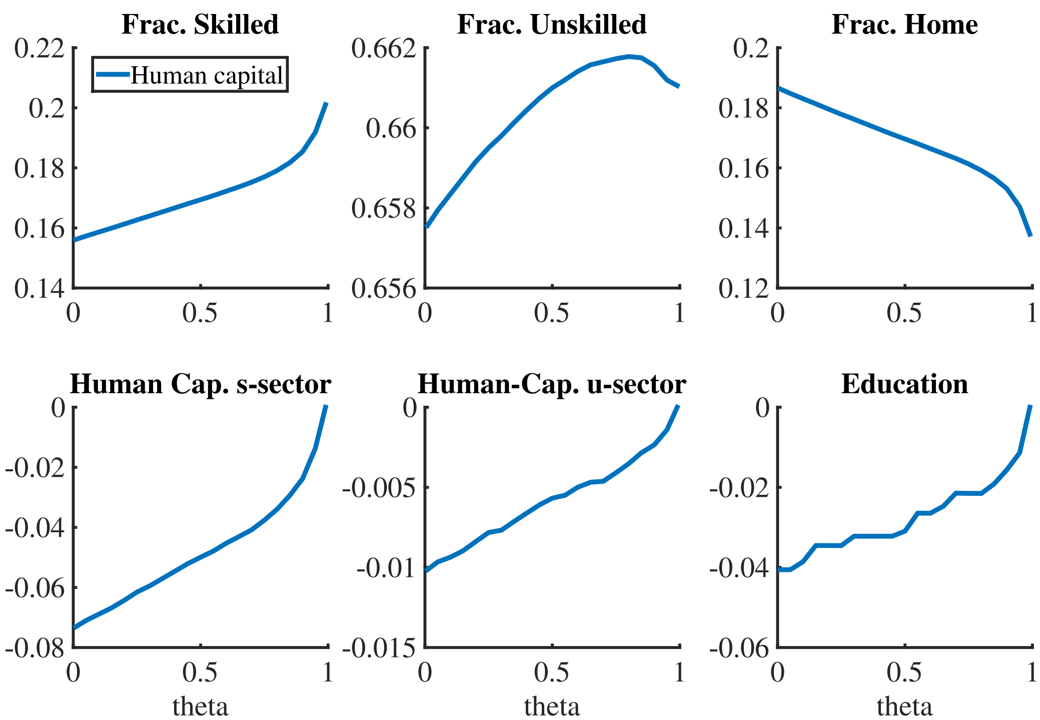


Figure 6: Labor supply decomposition in each sector.

5.2 With Non-Convexity

Non-convexities clearly magnify all the effects we have described above. Output falls by 22% in an economy without external finance, while the price of skilled labor falls by about 30%. In this economy the distinction between a model with and without an endogenous choice of human capital is even more striking.

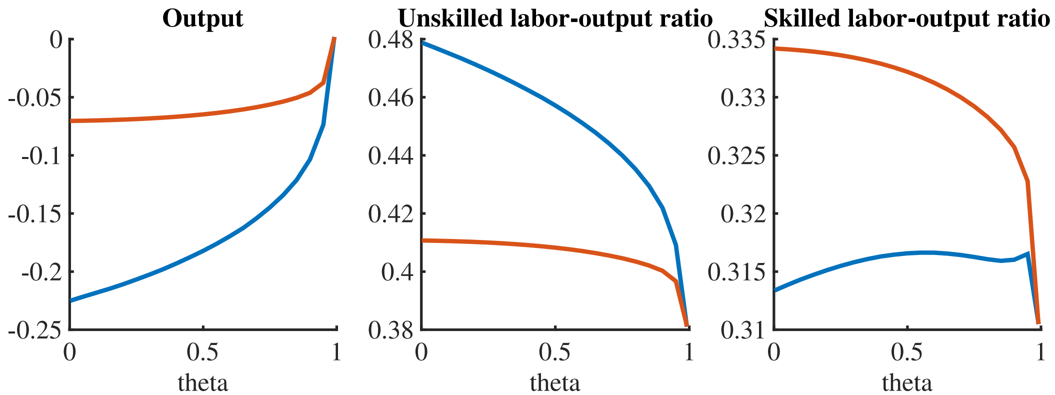


Figure 7: Output, effective labor supply in each sector divide by output

Figure 8: Price per-unit of human capital in each sector.

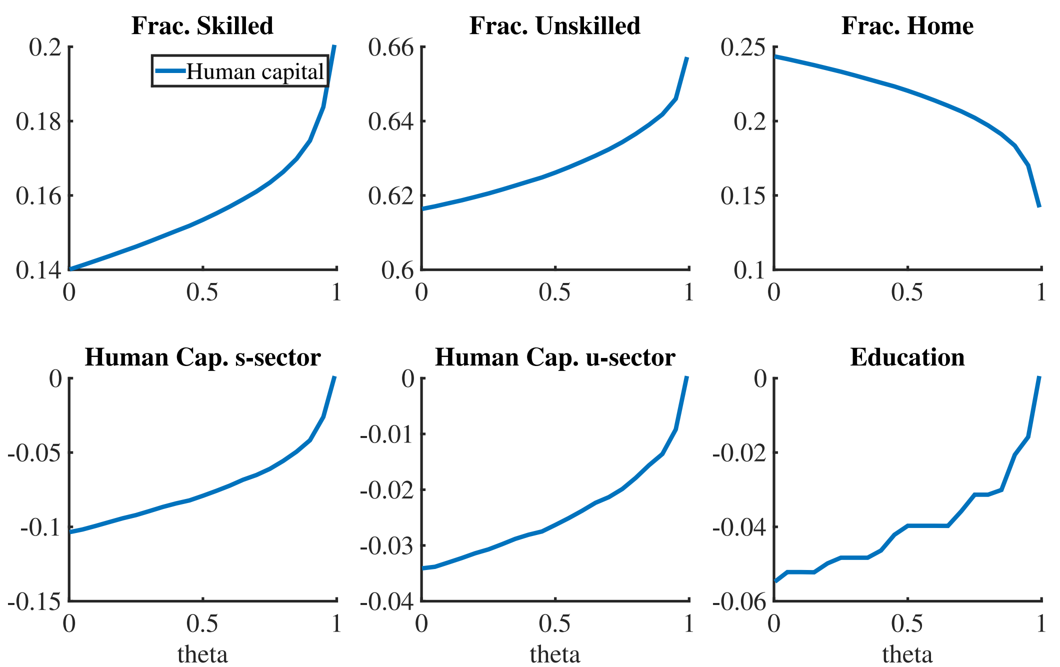


Figure 9: Labor supply decomposition in each sector.

6 Conclusions

We have argued that financial frictions have much larger detrimental effects of output per worker in economies in which capital and skills are complementary and agents make endogenous human capital accumulation decisions. A tightening of financial constraints reduces the price of skilled labor and thus the returns to human capital accumulation, significantly amplifying the output losses from financial frictions.

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