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Occupational choice, human capital, and financial constraints

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**Occupational Choice, Human Capital, and
Financial Constraints**

by

Rui Castro and Pavel Ševčík

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Occupational Choice, Human Capital, and Financial Constraints*

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Comments Welcome

Abstract

We study the aggregate productivity effects of firm-level financial frictions. Credit constraints affect not only production decisions but also household-level schooling decisions. In turn, entrepreneurial schooling decisions impact firm-level productivities, whose cross-sectional distribution becomes endogenous. In anticipation of future constraints, entrepreneurs under-invest in schooling. Frictions lower aggregate productivity because talent is misallocated across occupations, and capital misallocated across firms. In addition, firm-level productivities are also lower due to distortions induced by the schooling responses. We find that these effects combined account for about 1/5 of the U.S.-India aggregate productivity difference. Requiring the model to match schooling differences significantly amplifies the impact of frictions, and the model accounts for 58% of the aggregate productivity difference.

Keywords: Aggregate Productivity, Financial Frictions, Entrepreneurship, Human Capital.

JEL Codes: E24, I25, J24, O11, O15, O16, O47.

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1 Introduction

Total Factor Productivity (TFP) is the single most important factor accounting for the large cross-country income differences we see in the data (Hsieh and Klenow, 2010; Caselli, 2005; Hall and Jones, 1999; Klenow and Rodríguez-Clare, 1997). We evaluate the role of financial frictions as a source of TFP differences. The key friction is that entrepreneurs face a collateral constraint when raising business capital. Our main contribution is to consider the role of entrepreneurial schooling decisions, and how they interact with financial frictions.

We view entrepreneurial human capital as a main determinant of firm-level productivity. That is, more educated entrepreneurs are better managers, and therefore operate more productive businesses. In this setting, future entrepreneurs under-invest in schooling in anticipation of the presence of credit frictions. They do so because investing in schooling is not very productive in small-sized firms, and also because the opportunity cost of schooling investments is high when resources could be used instead to build up collateral. Intuitively, entrepreneurs don't invest much in education since they realize they will be running a small family business; they prefer instead to work hard in order to save more. Further, schooling investments get misallocated. That is, those entrepreneurs with the best productivity potential are the ones who feel compelled to reduce schooling investments the most. We find that these two effects, schooling under-investment and schooling misallocation, play an important quantitative role in accounting for the U.S.-India TFP differences.

Our model integrates two literatures/frameworks. One is a model of entrepreneurship with credit constraints, along the lines of Buera and Shin (2013), Buera *et al.* (2011) and Midrigan and Xu (2014), among others.¹ The other is a model of human capital accumulation along the lines of Erosa *et al.* (2010) and Manuelli and Seshadri (2014).

Like in the existing literature on entrepreneurship with credit constraints, financial frictions generate a misallocation of talent into occupations. Namely, poor individuals talented at entrepreneurship choose to become workers, since their firms would operate at an inefficiently small scale. Other individuals, not so talented at managing and operating a production technology, find it advantageous to do so if sufficiently wealthy. Further, capital gets

¹Other references include Castro *et al.* (2004, 2009), Erosa and Hidalgo-Cabrillana (2008), Amaral and Quintin (2010), Buera *et al.* (2011), Greenwood *et al.* (2013), Moll (2014), and Moll *et al.* (2014).

misallocated among those individuals that do decide to become entrepreneurs. This is because with credit constraints firm size depends on entrepreneurial wealth, not just firm-level productivities. On top of these well-understood effects of credit constraints, our framework generates additional ones, stemming from changes in entrepreneurial schooling choices and in the distribution of firm-level productivities. A key feature of our setup is precisely that the distribution of firm-level productivities becomes endogenous, determined by entrepreneurial-level schooling decisions.

We quantify the role of these different effects of credit frictions on TFP. In line with the previous literature, we first calibrate our model to the U.S. and consider a scenario where the only fundamental difference between the U.S. and India is the overall degree of financial frictions. In this case, our model accounts for about 1/5 of the U.S.-India TFP difference. Capital misallocation is responsible for roughly half of this difference. The other half comes mostly from the misallocation of entrepreneurial schooling investments. A second calibration also lets the average productivity of the human capital accumulation technology vary across the U.S. and India in order to match the average years of schooling differences across these two countries. This results in a significant amplification of the effect of frictions, and in this case the model is able to account for 58% of the TFP difference.

Our modelling of schooling decisions follows [Erosa *et al.* \(2010\)](#) and [Manuelli and Seshadri \(2014\)](#). These papers emphasize the role of cross-country TFP differences. Our model shares with these papers the feature that, in addition to time, expenditure in goods (or education quality) is also a key input into the human capital accumulation process. As in these papers, the education quality margin in our model leads workers to invest less in education in countries with lower wages (due to tighter credit frictions). In our paper, however, credit frictions also discourage schooling investments among entrepreneurs, by reducing the marginal return to those investments. The latter mechanism is independent from presence of an education quality margin in the human capital accumulation process.²

[Bhattacharya *et al.* \(2013\)](#) also consider entrepreneurial investment in managerial skills, in

²There is an extensive literature on educational decisions under credit constraints. An early example is [Galor and Zeira \(1993\)](#), and more recent developments are in [Lochner and Monge-Naranjo \(2011\)](#) and [Córdoba and Ripoll \(2013\)](#). As in these papers, credit constraints in our model act as a direct mechanism lowering education, namely among poorer individuals. However, the central role of credit constraints in our model will be in affecting entrepreneurial, not worker, schooling decisions.

a setting with exogenously given distortions in firm size. As in their paper, the distribution of firm-level productivities in our model arises endogenously from entrepreneurial investments in human capital. In contrast to their framework, firm size distortions are endogenous here, and depend on the wealth distribution. In our model, constrained entrepreneurs under-invest in schooling in part in order to self-finance. This mitigates physical capital misallocation across firms, a mechanism also emphasized by [Midrigan and Xu \(2014\)](#). Another difference is that, in our model, human capital investments are also a determinant of occupational choice decisions. The extent of under-investment in human capital by constrained entrepreneurs is therefore bounded by their willingness to switch occupation.

Finally, our paper is also related to the resource misallocation literature, namely [Restuccia and Rogerson \(2008\)](#), [Hsieh and Klenow \(2009\)](#), and [Bartelsman *et al.* \(2013\)](#). These authors examine the aggregate productivity consequences of misallocation generated by firm-specific taxes and subsidies. These taxes and subsidies are effectively stand-in, generic distortions, meant to capture deeper allocative problems. Our model concentrates on one such allocative problem: malfunctioning credit markets. We provide an explicit mapping between fundamental distortions coming out of our model, and the stand-in taxes and subsidies that are typically considered in this literature. We also extend [Hsieh and Klenow's \(2009\)](#) framework for measuring the extent of resource misallocation. In our case, in addition to distortions to cross-firm input allocation, there are also distortions to physical productivity relative to the frictionless benchmark. The latter are induced by talent misallocation and by distortions to entrepreneurial schooling investments. We find a significant quantitative role for the latter.

The paper is organized as follows. Section [2](#) describes the model. Section [3](#) analyzes the optimality conditions. Section [4](#) describes the calibration procedure. Section [5](#) presents the results, and Section [6](#) concludes. The Appendices contain detailed information about some of the analytical properties of the model, the mapping between model and data, and the numerical procedure.

2 Model

2.1 The Environment

Consider an economy with measure one of altruistic dynasties. Each individual lives for 2 periods, childhood and adulthood. The household, composed of a child and an adult parent, is the decision unit, as if a household planner existed which pooled all household member resources and coordinated all the decisions. We call childhood the period when schooling and investment decisions are made, and adulthood the period when the individual's main economic activity is carried out.

Households value stochastic aggregate household consumption streams according to

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_t). \quad (1)$$

The period utility function u is of class C^2 , is strictly increasing, strictly concave, and satisfies the usual Inada conditions.

In anticipation of our recursive formulation, we use primes to denote variables which pertain to the next generation, whereas those without primes refer to the current one. The household starts the period with wealth ω , and a draw of the child's abilities, current learning ability z and future entrepreneurial ability x . The inter-generational ability transmission is governed by a first-order Markov chain with transition probabilities $\pi(z', x' | z, x)$.

Given the current state (ω, z, x) , the household makes four decisions. First, it decides today's investment in the child's education, by choosing years schooling s and schooling expenditures e to produce human capital according to

$$h = z (s^\eta e^{1-\eta})^\xi, \quad (2)$$

with $\eta \in [0, 1]$ and $\xi \in [0, 1]$.³ We follow [Erosa *et al.* \(2010\)](#) and [Manuelli and Seshadri \(2014\)](#)

³A more general formulation would be $h = z (s^\eta e^{1-\eta})^\xi \bar{h}_0^\zeta + (1 - \mu) \bar{h}_0$, where \bar{h}_0 is the child's initial human capital. Here we assume full depreciation ($\mu = 1$), similarly to [Erosa *et al.* \(2010\)](#). The component \bar{h}_0^ζ is captured by mean learning ability in our specification. Intergenerational transmission of human capital is therefore governed by the persistence in learning ability.

in considering private expenditures as an input to human capital accumulation in addition to student time. This allows a worker's schooling time to increase with wages. With the presence of private expenditures, higher wages increase the marginal gain from schooling investments by more than the marginal cost, since the price of the goods input is invariant to the wage.⁴

Second, the household decides today's saving for next period, by purchasing bonds in net amount q at unit price $1/(1+r)$.⁵ Third, it decides the child's occupation for next period, whether to become an entrepreneur or a worker. Workers supply their human capital at the going wage rate. Entrepreneurs manage their own firms and are the residual claimants of profits. Fourth, if the decision is to become an entrepreneur next period then the household also needs to raise capital, possibly relying in part on external funds, and hire labor in order to run the firm.

All production is carried out by entrepreneurs according to

$$y = xh^\theta (k^\alpha l^{1-\alpha})^\gamma, \quad (3)$$

with $\alpha, \gamma, \theta \in (0, 1)$, where k and l denote physical capital and labor inputs. Entrepreneurial, or firm-level productivity is given by xh^θ , of which x is determined by luck, and h is the accumulated human capital. Physical capital depreciates at rate $\delta \in (0, 1)$.

2.2 Household's Problem

We focus on stationary equilibria, in which prices and the cross-sectional distribution over individual states are time-invariant. Denote by w the wage rate (unit price of human capital) and by r the real interest rate. We begin by formulating the household's problem conditional on the child's occupational choice. It is convenient to consider the occupational choice before

⁴As in [Erosa *et al.* \(2010\)](#), this mechanism also relies on the presence of tuition costs, which we also model. Tuition costs prevent the marginal gains and costs from an additional year of schooling to both vary proportionally with the current level of human capital, allowing schooling years to vary with both learning ability z and, via school quality adjustments, wages.

⁵Given our assumption on the resolution of uncertainty, saving is contingent upon the child's abilities, namely next period's entrepreneurial ability. We abstract from precautionary saving behavior associated with entrepreneurial ability risk in order to streamline the analysis. This allows us to characterize the household investment decisions via simple non-arbitrage conditions.

the remaining decisions. Since all uncertainty is resolved at the start of an individual's life, there is no loss in doing so.

Conditional on the child becoming a worker next period, the *worker-household's* problem can be written recursively as:

$$v^w(\omega, z, x) = \max_{c, e, s, q} \left\{ u(c) + \beta \sum_{z', x'} \pi(z', x' | z, x) v(\omega', z', x') \right\} \quad (\text{Pw})$$

subject to (2) and

$$c + ws\bar{l} + e + \frac{1}{1+r}q = w\psi h(1-s) + \omega \quad (4)$$

$$s \leq \bar{s} \quad (5)$$

$$q \geq -\lambda\phi\omega \quad (6)$$

$$\omega' \equiv wh + q. \quad (7)$$

Equation (4) is the budget constraint. The term $ws\bar{l} + e$ is the direct cost of investing in the child's education, composed of tuition fees $ws\bar{l}$ (\bar{l} is the total teacher input per unit of student time, which is a parameter) and expenditures in education quality e . Teacher's effective time is not an input into human capital production, only student time is. Expenditures in goods capture direct costs such as books and extracurricular activities. On the right-hand-side, $w\psi h(1-s)$ is the child's labor earnings, where $\psi \in (0, 1)$ captures increasing labor earnings over an individual's lifetime due to experience accumulation.

Equation (5) is the child's time constraint (our assumptions on preferences and human capital technology allow us to ignore the non-negativity constraints on consumption, time, and schooling expenditures). We impose an upper bound $\bar{s} \leq 1$ for quantitative purposes, to capture the fact that individuals do not normally spend their entire early life studying.

Households are subject to an inter-period *borrowing constraint* given by (6). They can only borrow up to a multiple $\lambda\phi \geq 0$ of their wealth.⁶ When $\phi = 0$ no borrowing is

⁶This constraint can be motivated by a simple static limited enforcement problem. Suppose a household borrows $-q > 0$ and then decides whether to default. The only penalty is that financial intermediaries may seize a fraction $\nu \in [0, 1]$ of total wealth, including the amount just borrowed. Intermediaries then require that the gain from defaulting does not exceed the cost, that is $-(1-\nu)q \leq \nu\omega$. This yields (6)

allowed, and investment must be completely funded out of the household's wealth; when $\phi = \infty$ (provided $\lambda > 0$, which we assume below) access to credit is unconstrained. Finally, equation (7) defines the initial wealth of the next household in the dynastic line, conditional on the fact that next period's parent will be a worker.

Similarly, conditional on the child becoming an entrepreneur next period, the *entrepreneur-household's* problem reads:

$$v^e(\omega, z, x) = \max_{c, e, s, q} \left\{ u(c) + \beta \sum_{z', x'} \pi(z', x' | z, x) v(\omega', z', x') \right\} \quad (\text{Pe})$$

subject to (2), (4), (5), (6) and a new definition of household's wealth which is now based on entrepreneurial profits

$$\omega' \equiv \Pi(q, h, x) + q, \quad (8)$$

where

$$\Pi(q, h, x) = \max_{k, l \geq 0} \{ x h^\theta (k^\alpha l^{1-\alpha})^\gamma - (r + \delta)k - wl \} \quad (\text{Pf})$$

subject to

$$k \leq \lambda q, \quad (9)$$

with $\lambda \geq 1$. Entrepreneurs hire capital and labor to maximize profits, subject to an intra-period *capital constraint*. The maximum level of capital an entrepreneur can use in production is given by a multiple λ of the household's second period wealth, which acts as collateral.⁷ When $\lambda = 1$ no external funding is allowed, and capital is solely determined by internal funds. When $\lambda = \infty$ financial markets work perfectly, and capital is not constrained by wealth.

with $\phi\lambda \equiv \nu/(1-\nu) \geq 0$. The main advantage from using this simple specification is tractability. It shares with self-enforcing limits based on dynamic incentives (Kehoe and Levine, 1993) the key feature that richer households are able to borrow more.

⁷We assume future profits are not pledgeable as collateral. Constraint (9) therefore implies that households that borrow today will not be able to run a firm tomorrow. As a result, only children from sufficiently wealthy backgrounds can aspire to become entrepreneurs. Similarly to (6), the constraint (9) may be motivated by a simple static limited enforcement problem. As in Buera and Shin (2013), suppose households borrow k from financial intermediaries against collateral q , and then have a decision whether to default. The only penalty is that intermediaries may seize the entire collateral, plus a fraction of κ of k . No default requires $(1-\kappa)k \leq q$, which yields (9) with $\lambda \equiv 1/(1-\kappa) \geq 1$. Related work using identical collateral constraints include Evans and Jovanovic (1989), Moll (2014) and Moll *et al.* (2014).

Financial frictions affect the model via (6) and (9). The parameter λ governs the overall extent of financial frictions in the economy, including raising capital by entrepreneurs, whereas ϕ is a parameter controlling the relative extent of consumer credit. We choose this formulation to reflect the possibility that seizing wealth upon default, for example, might be easier for one type of credit compared to the other. In our quantitative analysis we let λ vary across countries while fixing ϕ .

We finally consider the household's occupational choice for the child next period:

$$v(\omega, z, x) = \max \{v^w(\omega, z, x), v^e(\omega, z, x)\}. \quad (10)$$

2.3 Competitive Equilibrium

Definition. A stationary recursive competitive equilibrium is a set of value functions $v^w(\omega, z, x)$, $v^e(\omega, z, x)$, and $v(\omega, z, x)$, together with the associated decision rules, a set of entrepreneurial households B , prices w and r , and an invariant distribution over household states Ψ such that given prices,

- $v^w(\omega, z, x)$ and $v^e(\omega, z, x)$ solve problems (Pw) and (Pe), respectively, and $v(\omega, z, x)$ solves (10),
- the set of entrepreneur-households is defined by the optimal occupational choice rule:

$$B = \{(\omega, z, x) \in S \mid v^e(\omega, z, x) > v^w(\omega, z, x)\}, \quad (11)$$

where $S \subseteq \mathbb{R} \times \mathbb{R}_+^2$ is the individual household's state space,

- market for labor clears:

$$\int_B l d\Psi + \int_S s \bar{l} d\Psi = \int_{S \setminus B} h d\Psi + \int_S (1 - s) \psi h d\Psi, \quad (12)$$

- market for capital clears:

$$\int_B k d\Psi = \int_S \frac{q}{1 + r} d\Psi, \quad (13)$$

- market for goods clears:

$$\int_S c d\Psi + \int_S e d\Psi + \delta \int_B k d\Psi = \int_B x h^\theta (k^\alpha l^{1-\alpha})^\gamma d\Psi, \quad (14)$$

- distribution Ψ is invariant:

$$\Psi(\hat{S}) = \int_S P(X, \hat{S}) d\Psi(X) \text{ for all } \hat{S} \in \mathcal{B}_S, \quad (15)$$

where $P : S \times \mathcal{B}_S \rightarrow [0, 1]$ is a transition function generated by the decision rules and the stochastic processes for z and x , and \mathcal{B}_S is the Borel σ -algebra of subsets of S .

3 Analysis

In this section we present an analysis of individual optimal decisions. We start with entrepreneurial production decisions and proceed by backward induction to schooling and savings decisions. We finish with the occupational choice.

3.1 Production

Given their human capital, entrepreneurs hire labor and capital to maximize their profits. The presence of the capital constraint implies that the profit function will differ for constrained and unconstrained entrepreneurs:

$$\Pi(q, h, x) = \begin{cases} \Pi^*(h, x) & \text{if } q \geq q^*(h, x) \text{ (unconstrained)} \\ \Pi^c(q, h, x) & \text{else (constrained),} \end{cases} \quad (16)$$

where

$$\begin{aligned}
q^*(h, x) &= k^*/\lambda \\
k^* &= \left[\frac{(1-\alpha)(r+\delta)^{1-\frac{1}{(1-\alpha)\gamma}}}{\alpha w} \right]^{(1-\alpha)\frac{\gamma}{1-\gamma}} (\alpha\gamma x h^\theta)^{\frac{1}{1-\gamma}} \\
l^* &= \frac{(1-\alpha)(r+\delta)}{\alpha w} k^* \\
y^* &= x h^\theta ((k^*)^\alpha (l^*)^{1-\alpha})^\gamma \\
\Pi^*(h, x) &= y^* - w l^* - (r+\delta) k^* \\
&\equiv A (x h^\theta)^{\frac{1}{1-\gamma}}
\end{aligned} \tag{17}$$

with A being a function of production function parameters and factor prices, and

$$\begin{aligned}
k^c &= \max\{\lambda q, 0\} \\
l^c &= \left[\frac{\gamma(1-\alpha)(k^c)^{\alpha\gamma}}{w} x h^\theta \right]^{\frac{1}{1-(1-\alpha)\gamma}} \\
y^c &= x h^\theta ((k^c)^\alpha (l^c)^{1-\alpha})^\gamma \\
\Pi^c(q, h, x) &= y^c - w l^c - (r+\delta) k^c \\
&\equiv B(q) (x h^\theta)^{\frac{1}{1-(1-\alpha)\gamma}} - (r+\delta) \lambda q
\end{aligned} \tag{18}$$

with $B(q)$ also a function of production function parameters and factor prices, in addition to saving.⁸ The constrained profit function is increasing in accumulated assets since higher q allows the entrepreneur to raise more capital and increase the scale of the firm closer to its optimal level.

3.2 Schooling/Saving Decisions

In our framework, schooling and savings are investments into two different assets (human and physical capital). Our timing assumption allows us to characterize different investment opportunities in terms of simple non-arbitrage equations that transpire from the first-order optimality conditions for problems (Pw) and (Pe) with respect to s , e , and q . Financial

⁸ The expressions for A and $B(q)$ can be found in Appendix A.

frictions will later on be represented as wedges distorting these conditions.

The first-order conditions read:⁹

$$-\mu + w \left(\bar{l} + \psi h - \psi (1-s) \eta \xi \frac{h}{s} \right) u'(c) = \beta \sum_{z', x'} \pi(z', x' | z, x) v_1(\omega', z', x') \omega'_2(q, h, x) \eta \xi \frac{h}{s} \quad (19)$$

$$\left(1 - w \psi (1-s) (1-\eta) \xi \frac{h}{e} \right) u'(c) = \beta \sum_{z', x'} \pi(z', x' | z, x) v_1(\omega', z', x') \omega'_2(q, h, x) (1-\eta) \xi \frac{h}{e} \quad (20)$$

$$-\nu + \frac{1}{1+r} u'(c) = \beta \sum_{z', x'} \pi(z', x' | z, x) v_1(\omega', z', x') \omega'_1(q, h, x), \quad (21)$$

where μ and ν are the Lagrange multipliers on the time constraint (5) and the borrowing constraint (6), respectively. These equations apply conditional on either occupation, only the partial derivatives of future wealth with respect to saving and human capital, respectively ω'_1 and ω'_2 , differ across worker and entrepreneur households.

Combining (19) and (20) allows us to obtain unconstrained schooling time as an implicit function $\hat{s}(e, z, w)$ of schooling expenditures,

$$w (\bar{l} + \psi h) = \frac{\eta}{1-\eta} \frac{e}{\hat{s}},$$

where \hat{s} is strictly increasing in e . Schooling time is

$$s(e, z, w) = \min \{ \hat{s}(e, z, w), \bar{s} \}, \quad (22)$$

yielding human capital

$$h(e, z, w) = z (s(e, z, w)^\eta e^{1-\eta})^\xi. \quad (23)$$

Combining (20), (21), and (23) gives us a non-arbitrage condition equating the returns to

⁹Notice that v_1 is always defined at the optimum. Even though v has a kink in the wealth dimension induced by the occupational choice, the optimum will never occur at this kink. It follows that, at the optimum, v_1 is either equal to v_1^w or to v_1^e . Notice also that, with sufficient smoothness introduced by the ability shocks, which we assume, the first-order conditions are not only necessary but also sufficient for an optimum. See Clausen and Strub (2013) for a formal discussion.

physical and human capital accumulation:

$$-\tilde{\nu} + (1 - \eta) \xi \frac{h(e, z, w)}{e} \omega'_2(q, h(e, z, w), x) = (1 + r) p_e(h, s, e) \omega'_1(q, h(z, e), x), \quad (24)$$

where for convenience we denote the shadow unit price of schooling expenditures to be

$$p_e = p_e(h, s, e) \equiv 1 - w\psi(1 - s(e, z, w))(1 - \eta) \xi \frac{h(e, z, w)}{e}, \quad (25)$$

as it equals the unit of foregone consumption less the marginal increase in first-period earnings, and $\tilde{\nu} \equiv \nu(1 + r) p_e / (\beta \sum_{z', x'} \pi(z', x' | z, x) v_1(\omega', z', x'))$. Specializing equation (24) for each occupation allows us to characterize the optimal schooling decisions for worker and entrepreneur households.¹⁰

3.2.1 Worker-Household

For a worker-household we have

$$\omega'_1(q, h, x) = 1 \text{ and } \omega'_2(q, h, x) = w. \quad (26)$$

As workers, all individuals have the same constant returns to human capital accumulation since wages are linear in worker's human capital. If the borrowing constraint does not bind ($q < -\lambda\phi\omega$ and $\tilde{\nu} = 0$), then we can substitute (26) in (24) and optimal schooling expenditures solve:

$$\frac{w}{1 + r} (1 - \eta) \xi \frac{h}{e} = p_e, \quad (27)$$

with $h = h(e, z, w)$ and $s = s(e, z, w)$. The left-hand-side is the discounted future benefit of investing an extra unit of the final good on education, which is the wage rate times the marginal increase in human capital. The right-hand-side is the marginal cost, which is the unit of the good invested less the marginal increase in labor earnings enjoyed in the current

¹⁰A sufficient condition for the existence of an optimal solution is that $\frac{\theta}{1-\gamma}(1-\eta)\xi < 1$, which we assume throughout. This condition always holds for worker households, who have linear returns on human capital (equivalent to setting $\theta = 1 - \gamma$ in the condition). For entrepreneur households it is automatically satisfied if, for example, the entrepreneurial production function (3) has constant returns to scale in all variable inputs, i.e. $\theta = 1 - \gamma$. Increasing returns are admissible as long as the human capital accumulation technology exhibits sufficient curvature.

period.¹¹

If instead the borrowing constraint binds ($q = -\lambda\phi\omega$ and $\tilde{v} > 0$), then the worker-household's optimal expenditure solves:

$$\max_e \left\{ u \left(\omega - e - w (s\bar{l} - \psi h (1 - s)) + \frac{1}{1+r} \lambda\phi\omega \right) + \beta \sum_{z', x'} \pi(z', x' | z, x) v(wh - \lambda\phi\omega, z', x') \right\} \quad (28)$$

where $s = s(e)$ and $h = h(z, e)$ are given respectively by (22) and (23). In contrast to the unconstrained case, the optimal schooling expenditures of a credit-constrained worker-household depends on current wealth ω .

3.2.2 Entrepreneur-Household

The capital constraint (9), together with the condition that $k \geq 0$, implies that entrepreneur-households will always have $q > 0$ and therefore will never be credit-constrained. We have:

$$\omega'_1(q, h, x) = \begin{cases} 1 + \frac{\partial \Pi^c}{\partial q}(q, h, x) & \text{if } q \in (0, q^*(h, x)), \\ 1 & \text{if } q \geq q^*(h, x), \end{cases} \quad (29)$$

and

$$\omega'_2(q, h, x) = \begin{cases} B(q) \frac{\theta}{\alpha\gamma+1-\gamma} (xh^\theta)^{\frac{1}{\alpha\gamma+1-\gamma}} h^{-1} & \text{if } q \in (0, q^*(h, x)), \\ A \frac{\theta}{1-\gamma} (xh^\theta)^{\frac{1}{1-\gamma}} h^{-1} & \text{if } q \geq q^*(h, x). \end{cases} \quad (30)$$

From (29) and (30) we can deduce how the marginal returns to physical and human capital accumulation vary with the entrepreneur-household's saving q . We obtain the following result.

Proposition 1. *Given h , capital-constrained entrepreneur-households (with $q < q^*(x, h)$) face a higher marginal return to physical capital accumulation and a lower marginal return to human capital accumulation than unconstrained entrepreneur-households (with $q \geq q^*(x, h)$).*

¹¹This condition also characterizes human capital investment decisions of unconstrained individuals (workers) in Erosa *et al.* (2010). Our paper draws attention to the impact of financial frictions on the education decisions of entrepreneur-households.

Proof. The first part of the proposition follows from (29), the fact that $\frac{\partial \Pi^c(q, h, x)}{\partial q}$ is decreasing in q , and that $\frac{\partial \Pi^c}{\partial q}(q^*(h, x), h, x) = 0$. The second part follows from (30), the fact that $B(q)$ is increasing in q , and that $B(q^*(h, x)) \frac{\theta}{\alpha\gamma + 1 - \gamma} (xh^\theta)^{\frac{1}{\alpha\gamma + 1 - \gamma}} = A \frac{\theta}{1 - \gamma} (xh^\theta)^{\frac{1}{1 - \gamma}}$. \square

The intuition behind the first part of Proposition 1 is that, for capital-constrained entrepreneur-households, saving relaxes the capital constraint and allows them to expand their firms closer to the optimal unconstrained scale. The second part holds because human and physical capital are complementary in production. Capital-constrained entrepreneur-households employ less capital, making their human capital less productive.

Proposition 1 shows how the capital constraint distorts saving and schooling decisions of entrepreneur-households. These households have an incentive to save more and invest less in education compared to unconstrained entrepreneur-households.

Substituting ω'_1 and ω'_2 for the case of $q \geq q^*(h, x)$ into (24) yields the condition for optimal schooling expenditures of capital-unconstrained entrepreneur-households:

$$\frac{A}{1 + r} (1 - \eta) \xi \frac{\theta}{1 - \gamma} \frac{(xh^\theta)^{\frac{1}{1 - \gamma}}}{e} = p_e.$$

This condition is analogous to (27), with the left-hand side representing now the discounted marginal increase in future profits from investing an additional unit of the final good on schooling.

Analogously, we may replace ω'_1 and ω'_2 for the case of $q \in (0, q^*(h, x))$ into (24) to obtain the optimal schooling expenditures for capital-constrained entrepreneur-households:

$$\frac{B(q)}{1 + r} (1 - \eta) \xi \frac{\theta}{\alpha\gamma + 1 - \gamma} \frac{(xh^\theta)^{\frac{1}{\alpha\gamma + 1 - \gamma}}}{e} = p_e \left(1 + \frac{\partial \Pi^c}{\partial q}(q, h, x) \right).$$

Compared to the unconstrained case, the marginal gain from investing in education is lower, and decreasing returns set in faster (Proposition 1). The marginal cost is also higher, since investing in education sacrifices wealth accumulation, which lowers firm capital and hence profits. Optimal spending in education therefore depends on household wealth, via saving q . Higher wealth helps relax the capital constraint, and reduces investment and schooling

distortions.

4 Calibration

We focus on the comparison between the U.S. and India. Our baseline strategy is similar to Buera and Shin’s (2013), in the sense that we first calibrate the model economy to the U.S. and then vary the financial friction λ , holding the remaining parameters constant, in order to match India’s ratio of external finance to output. We call this the *benchmark* India calibration.

We consider an alternative *schooling* calibration where we also allow the mean of the learning ability distribution, \bar{z} , to vary between the U.S and India, in order to match India’s average years of schooling. The purpose of this exercise is to ask how far we go in accounting for the U.S.-India differences in production outcomes, namely TFP, assuming we are able to account for schooling differences. We view cross-country differences in \bar{z} as representing differences in schooling quality not captured by current private expenditures. These could be due to differences in public school quality, or differences in private or public school infrastructure.

Our baseline parameters are described in Table 1. The first-order Markov chain governing abilities is obtained from the discretization of a VAR(1) in logs where

$$\begin{aligned}\ln(z_{t+1}/\bar{z}) &= \rho_z(z_t/\bar{z}) + \varepsilon_{t+1}^z, \\ \ln(x_{t+1}/\bar{x}) &= \rho_x(x_t/\bar{x}) + \varepsilon_{t+1}^x,\end{aligned}$$

and the disturbances are normally distributed with variance-covariance matrix

$$\Sigma = \begin{pmatrix} \sigma_z^2 & \sigma_{zx} \\ \sigma_{zx} & \sigma_x^2 \end{pmatrix}.$$

We employ the procedure described by Tauchen and Hussey (1991), with 15 states for entrepreneurial ability and 4 states for learning ability.

We take one model period to be 30 years. Individuals start life at age 6. The period going

from age 6 until age 36 (childhood) is when schooling and early working in the labor market take place. The period going from age 36 until retirement age 66 (adulthood) is when the main economic activity, entrepreneurship or working for a wage, takes place.

Some parameters are calibrated externally to the model. These are in the top block of Table 1. We normalize average entrepreneurial ability to 1. The coefficient of relative risk aversion belongs to the interval of available estimates, and is a standard value in quantitative analysis, as is the rate of physical capital depreciation. The parameters governing the income share of capital (α) and the income share of entrepreneurial income (γ) are also standard in models of entrepreneurship (see for example [Atkeson and Kehoe, 2005](#), [Restuccia and Rogerson, 2008](#), and [Buera and Shin, 2013](#)).¹² We set the autocorrelation coefficient of learning ability to the intergenerational correlation coefficient of IQ scores reported by [Bowles and Gintis \(2002\)](#), between the average parental IQ score and the average offspring IQ score. Finally, we impose an upper bound on schooling time corresponding to 20 years of formal schooling.

The remaining 14 parameters are chosen in order to minimize the sum of squared percentage deviations of 14 data moments from their model analogues. The bottom block of Table 1 shows the values for these parameters, as well as the model’s success in matching the data moments. As is common in this type of analysis, we identify each parameter with a moment which we believe is particularly helpful in identifying it, although in the end all parameters are jointly determined through a fairly complex system of nonlinear equations.

When computing the moments in the model, we take into consideration the overlapping generations structure of our framework, and the fact that young household members split their time endowment between formal schooling and work. Specifically, we assume a survey protocol in our model in which agents report information only at the end of each model period. In this case, individuals reporting to be workers in the model are all young household members, irrespective of their future occupation, plus adult household members who chose to work for a wage during the second period of their lives. Individuals reporting to be

¹²In our model with decreasing returns to scale income accrues to capital, labor, and the entrepreneurial input. We attribute the latter to capital and labor incomes, in shares α and $1 - \alpha$ respectively. We therefore equate α to the aggregate capital income share value.

Table 1: Benchmark calibration

| Parameter | Value | Target | Data | Model |
|-----------------------------|-------|---|-------|-------|
| <i>External calibration</i> | | | | |
| σ | 1.0 | direct estimates | | |
| δ | 0.844 | yearly depreciation rate of 6% | | |
| α | 1/3 | capital income share | | |
| \bar{x} | 1.0 | normalization | | |
| γ | 0.85 | direct estimates | | |
| ρ_z | 0.72 | intergenerational correlation of IQ scores | | |
| \bar{s} | 2/3 | up to 20 years of formal schooling (ages 6-26) | | |
| <i>Internal calibration</i> | | | | |
| β | 0.215 | yearly real interest rate | 0.04 | 0.037 |
| \bar{z} | 51.6 | average years of schooling among entrepreneurs | 13.9 | 13.6 |
| ξ | 0.85 | average years of schooling among workers | 13.7 | 14.2 |
| σ_z | 0.09 | earnings share of top 5% | 0.35 | 0.32 |
| η | 0.81 | output share of schooling expenditures | 0.045 | 0.047 |
| \bar{l} | 7.09 | output share of teacher and staff compensation | 0.05 | 0.046 |
| ψ | 0.6 | average labor earnings at age 46 over average at age 26 | 1.75 | 1.75 |
| θ | 0.16 | entrepreneurship rate | 0.096 | 0.05 |
| ρ_x | 0.45 | intergenerational correlation of entrepreneurship | 0.32 | 0.29 |
| σ_x | 0.25 | employment share of top 5% establishments | 0.57 | 0.51 |
| σ_{xz} | -0.1 | ratio of median earnings (entrepreneurial over labor) | 0.94 | 1.0 |
| ϕ | 0.005 | share of household credit in total external finance | 0.19 | 0.21 |
| $\lambda_{U.S.}$ | 9.22 | ratio of external finance to output | 2.91 | 2.25 |
| λ_{India} | 1.30 | ratio of external finance to output | 0.46 | 0.45 |

entrepreneurs are only adult household members who chose this occupation.¹³ We also take one entrepreneurial firm in the model as corresponding to an establishment in the data.

We comment on each of the moments we have selected. A yearly real interest rate of 4% is roughly between the real return on riskless bonds and the real return on equity over a long horizon. Based on CPS (Current Population Survey) data, [Levine and Rubinstein \(2015\)](#) report three relevant summary statistics: a rate of entrepreneurship (fraction of individuals reporting to be self-employed) of 9.6%, average years of schooling of both entrepreneurs and

¹³For example, this implies that the rate of entrepreneurship in the model equals $1/2 \int_B d\Psi$, where the division by 2 arises because, every period, each household is endowed with two time endowments of one unit each.

workers around 14, and a ratio between the median annual earnings among entrepreneurs to the median across workers of 0.9402.¹⁴ This moment is key at identifying a slightly negative covariance between innovations to learning and entrepreneurial abilities. Meaning that households with high learning ability tend to have a slight disadvantage at entrepreneurship. A higher covariance would imply a larger earnings ratio for entrepreneurs over workers compared to the data.

For the output share of (public and private) schooling expenditures we use the same number as [Manuelli and Seshadri \(2014\)](#), and for the output share of teacher and staff compensation we use the same number as [Erosa *et al.* \(2010\)](#). The ratio of average labor earnings at age 46 over the ratio at age 26 comes from Figure 1 of [Kambourov and Manovskii \(2009\)](#). It is based upon the PSID (Panel Study of Income Dynamics) and refers to the cohort entering the labor market in 1968. The intergenerational correlation of entrepreneurial occupation is reported by [Dunn and Holtz-Eakin \(2000\)](#), and corresponds to the fraction of sons of self-employed fathers in the NLS (National Longitudinal Surveys) who were themselves self-employed at some point in the sample.

The employment share of the top 5% establishments is reported by [Henly and Sanchez \(2009\)](#), based upon the U.S. Census County Business Pattern series. This figure is across establishments in all sectors of activity in the year 2006. The number for the earnings share of the top 5% comes from [Díaz-Giménez *et al.* \(2011\)](#) and is based on the Survey of Consumer Finances.

The ratio of total external finance (including private credit) to output in the U.S. is obtained from the 2013 update of the [Beck *et al.* \(2000\)](#) financial indicators database. We adjust the reported stock market capitalization by the average book-to-market ratio, following [Buera *et al.* \(2011\)](#). Our number is the average over the years 1990-2011. Our other financial market indicator is the share of household credit in total external financing. We obtained this value as the product between the share of household credit in total credit in 2005 from the [International Monetary Fund \(2006\)](#), and the share of total credit in total external financing from the 2013 update of the [Beck *et al.* \(2000\)](#) data set, again averaged

¹⁴[Levine and Rubinstein \(2015\)](#) also report a ratio of average annual earnings between the two occupations of 1.25, indicating a significantly more skewed earnings distribution among entrepreneurs. Our model is consistent with this fact.

over the years 1990-2011.

Finally, in our schooling calibration we obtain $\lambda_{India} = 1.27$, and $\bar{z}_{India} = 14.13$, which is about one quarter of the U.S. value. With these parameters, we are able to exactly match India's ratio of external finance to output of 0.46, and India's average years of schooling of 5.26.

5 Results

5.1 Allocative Consequences of Financial Constraints

We begin with a qualitative analysis of the allocative effects of financial frictions. In the absence of frictions, the wealth distribution should play no role in resource allocation, which should depend only on the distribution of abilities. With financial frictions, the wealth distribution interferes with resource allocation. We illustrate the different types of distortions that arise in the model economy. We plot some of the model's decision rules, for the U.S. and India (benchmark calibration), at each time varying one of the states while holding the remaining two constant. Our focus is on household-entrepreneurs.

5.1.1 Misallocation of Talent

The occupational choice is displayed in Figure 1. The left panel shows that low wealth makes some ability types in India choose to become workers, whereas they engage in entrepreneurship in the U.S. This is because financial constraints are tighter in India. The right panel shows that, both in the U.S. and in India, only individuals with sufficiently high entrepreneurial ability become entrepreneurs. However, the entrepreneurial ability cutoff is lower in India. Since input prices are lower in India (general equilibrium effect) this encourages some of the marginal ability types to become entrepreneurs. No selection effects are evidenced in the middle panel for learning ability, an outcome which is specific to the particular state we are looking at.

Figure 1 illustrates two forces underlying the misallocation of talent in the economy: financial frictions discourage some good types from becoming entrepreneurs in India, whereas

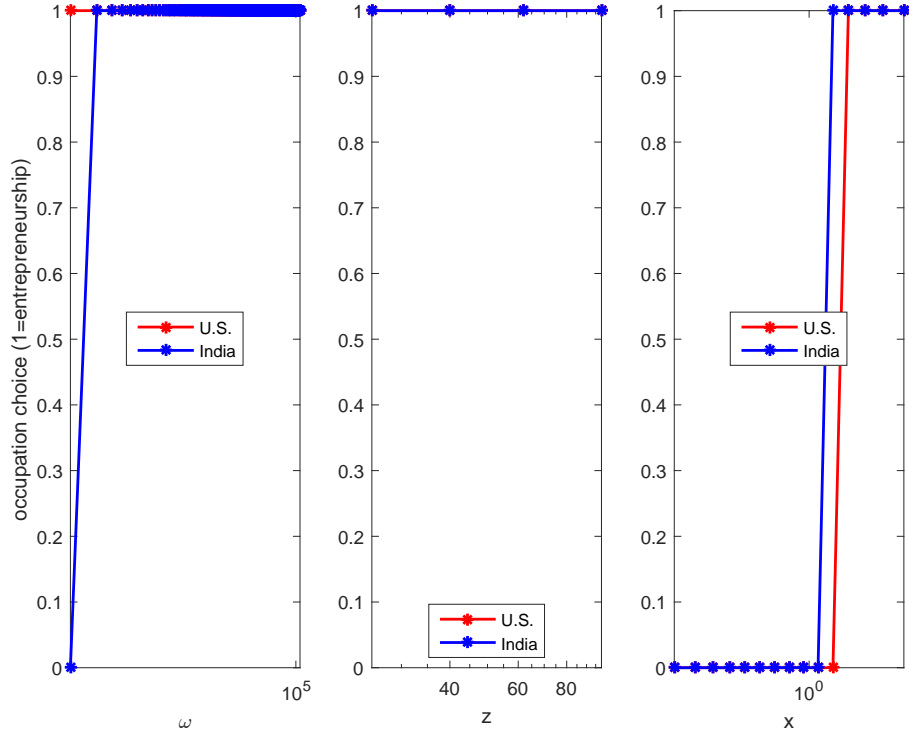


Figure 1: Entrepreneurship rate across ability and wealth

they encourage some bad types to engage in this activity. The resulting selection of types into entrepreneurship is worse in India.

In net terms, the effect of attracting bad types into entrepreneurship dominates the effect of discouraging good types, and the entrepreneurship rate is higher in India (6.5%) compared to the U.S. (5%).

5.1.2 Production Distortions

Figure 2a displays the level of production depending on the current entrepreneurial state. The left panel shows that, for sufficiently rich individuals, production is independent from wealth. For them, production is higher in India because input prices are lower. Among poorer individuals, instead, production declines with wealth. This happens at a faster rate in India, where financial constraints are tighter. Tighter constraints lower production both because firm size is lower, but also because firm-level productivity xh^θ is lower. The latter is due to the fact that entrepreneurs under-invest in education. For the very poorest, these

effects lead to output losses in India compared to the U.S.

The middle and right panels of Figure 2a show that, for given wealth, production increases with both learning and entrepreneurial abilities. However, they increase at a faster pace in the U.S. As ability levels increase, constraints become tighter, particularly in India. When ability is higher, entrepreneurs in India are constrained to make more significant size reductions relative to the optimum, and sacrifice schooling more, resulting in lower firm-level productivity.

The behavior of capital-output ratios in Figure 2b is consistent with this discussion. Capital drops relative to output when entrepreneurs are constrained, which happens particularly in India, and relatively poor and high-ability individuals. Absent financial constraints, capital-output ratios should be independent from wealth, as well as from learning or entrepreneurial ability.

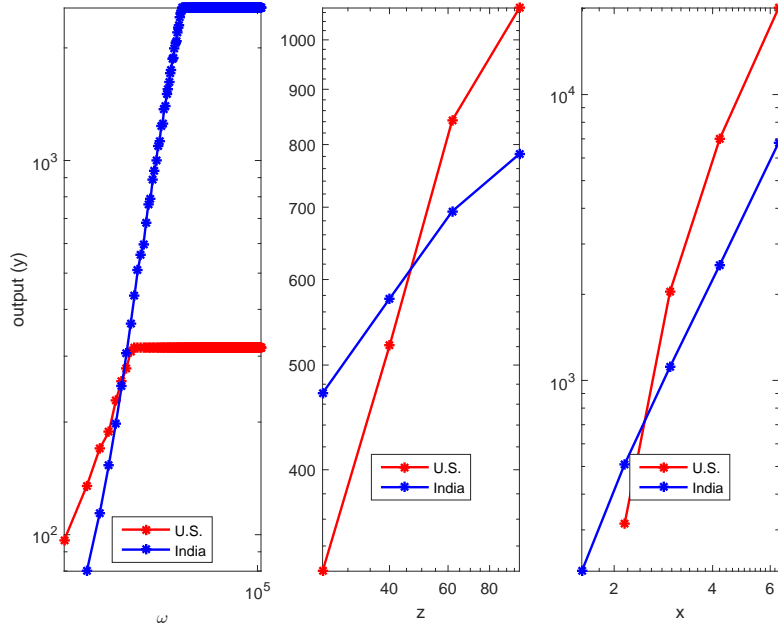
Notice that endogenous schooling works to mitigate some of the effects of credit constraints on production. Although higher ability households do tend to be more credit-constrained, in our model they are able to respond by sacrificing schooling investments. This allows them to accumulate more wealth thereby relaxing credit constraints. Capital-output ratios do not decline as much as they would otherwise, without schooling responses, and production distortions tend to be lower.¹⁵ We illustrate these schooling responses next.

5.1.3 Investment Distortions

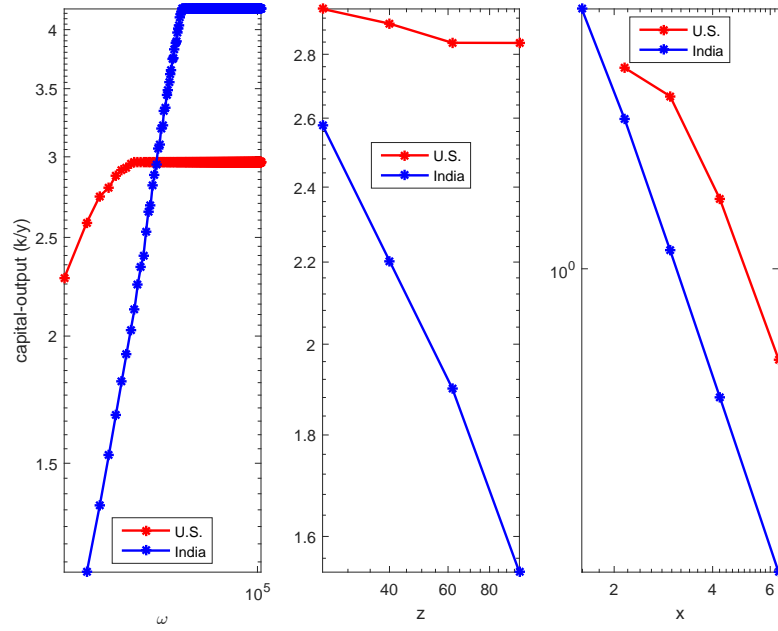
We display the saving and schooling expenditure decisions of entrepreneurs, as a function of wealth, in Figure 3a. For sufficiently wealthy households, saving increases with wealth, and is higher in the U.S. because of a higher interest rate. As wealth diminishes, at some point the constraint on capital tomorrow will bind (the kink in the saving decision rule). This arises earlier in India compared to the U.S., given tighter constraints in India. At this point, in order to build more collateral, entrepreneurs save more today than they would normally do.

The right panel of Figure 3a illustrates the under-investment in schooling by constrained

¹⁵This feature is related to Midrigan and Xu (2014), who emphasize the role of self-financing in mitigating the effect of credit frictions on capital misallocation. Our setup allows for self-financing to adjust to frictions not only through declines in current consumption, but also in schooling.



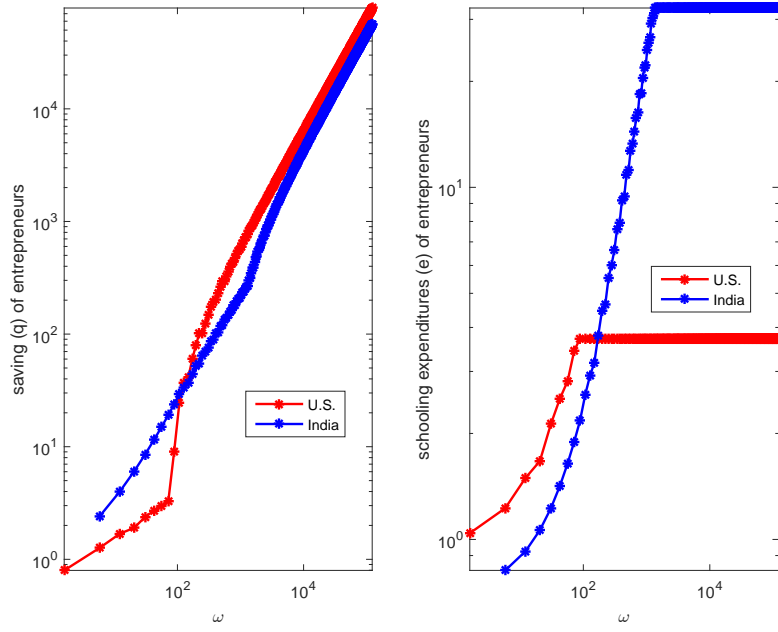
(a) Production (y)



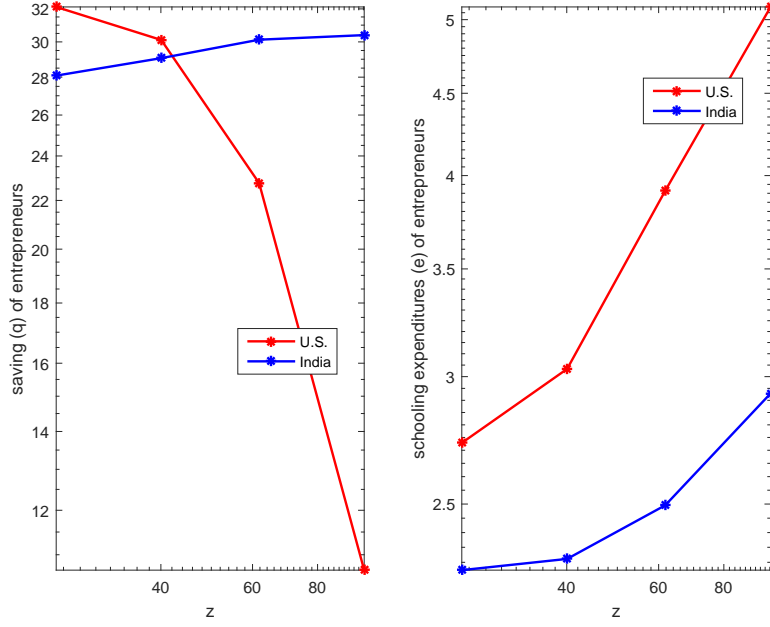
(b) Capital-output ratios (k/y)

Figure 2: Production and capital-output ratios across ability and wealth

entrepreneurs. In sufficiently wealthy households, schooling depends only on learning and entrepreneurial abilities, not on wealth. Expenditure levels are higher in India, once again



(a) Saving and schooling against wealth



(b) Saving and schooling against learning ability

Figure 3: Saving and schooling expenditures of entrepreneurs

because of lower input prices: optimal firm size is higher in India for these individuals, increasing the marginal return to education. Among poorer households, however, schooling

declines with wealth. This happens both because of a lower marginal return to schooling investments, and a higher opportunity cost. Constrained entrepreneurs would rather build collateral than spend on education.

Figure 3b gives some further indication of how financial frictions distort saving and schooling decisions. Both in the U.S. and in India, schooling increases with learning ability. However, the slope of the profile is higher in the U.S. In this country, as learning ability increases, entrepreneurs are willing to cut back on saving and devote more resources to schooling, see right panel of Figure 3b. Not the case in India, where higher learning ability also means a tighter constraint on firm size, leading entrepreneurs not only to increase schooling expenditures by less, but also to actually increase saving. All of this in an attempt to build more collateral for the next period and relax frictions.

5.2 Measuring Misallocation

We rely on the framework of Hsieh and Klenow (2009) to gauge the extent of misallocation in our model. That is, we will capture the extent of model-driven production and investment distortions by means of generic distortions affecting a simple stand-in firm decision problem.

In broad terms, our strategy follows in two steps. First, we show that the generic production distortions considered by Hsieh and Klenow (2009) do have a specific interpretation in terms of our model. Second, we use and extend Hsieh and Klenow’s (2009) framework to decompose the extent of model-based TFP differences in terms of average firm-level productivity and input misallocation effects.

Hsieh and Klenow (2009) focus on revenue productivity (TFPR) as a measurement tool, following Foster *et al.* (2008). This notion of total factor productivity is obtained by dividing nominal production revenue by an appropriate measure of production inputs. As Hsieh and Klenow (2009) show, the distribution of TFPR across production units is particularly informative about misallocation. In the benchmark case of no frictions, this distribution is degenerate, as TFPR reflects only factors which are common across production units, such as market prices and common technological parameters. Importantly, TFPR does not reflect differences in real, or physical productivity across units (TFPQ in the literature’s terminology), it only reflects unit-specific deviations from marginal product equalization. As

we shall show, under some conditions a more dispersed TFPR distribution is associated with a higher the degree of misallocation frictions. A more dispersed TFPR distribution indicates larger TFP gains may be obtained by reallocating the existing aggregate level of production inputs away from low and towards high TFPR firms.

Our first goal is precisely to compute model-based distributions of TFPQ and TFPR in order to characterize firm-level productivity and input misallocation effects in the production sector. Our approach provides an explicit mapping between TFPQ and TFPR, and deeper financial frictions.

5.2.1 Basic Model Wedges

Financial frictions distort decisions by introducing what amounts to individual-level wedges in the optimality conditions that would emerge in the frictionless case. We call them basic distortions, or *basic model wedges*. We first identify these basic wedges, and then show how they map into proxy, or stand-in misallocation wedges. The latter are generic wedges featured in much of the misallocation literature, for example [Restuccia and Rogerson \(2008\)](#), [Hsieh and Klenow \(2009\)](#) and [Bartelsman *et al.* \(2013\)](#), among many others. Since our focus is on production distortions, we shall concentrate on entrepreneur-households.

The entrepreneur-household's optimality conditions under frictions (Section 3.2) can be re-written as their counterpart absent frictions, distorted by two basic individual-level wedges which we label τ_q^e and τ_h^e :

$$u'(c) = \beta (1 + r) (1 + \tau_q^e) \sum_{z', x'} \pi(z', x' | z, x) v_1(\omega', z', x'), \quad (31)$$

$$p_e u'(c) = \beta (1 - \eta) \xi (1 - \tau_h^e) \frac{\theta}{1 - \gamma} A \frac{(x h^\theta)^{\frac{1}{1-\gamma}}}{e} \sum_{z', x'} \pi(z', x' | z, x) v_1(\omega', z', x'). \quad (32)$$

These equations define two basic wedges for the entrepreneur-household as a function of the current state. These wedges capture distortions to the marginal value of future wealth of additional saving and human capital levels due to the presence of financial constraints, as described by (29) and (30). They replicate the optimality conditions (20) and (21) for

constrained entrepreneurs provided that

$$\begin{aligned}\tau_q^e &= \begin{cases} \partial \Pi^c(q, h, x) / \partial q & \text{if } q \in (0, q^*(h, x)), \\ 0 & \text{if } q \geq q^*(h, x), \end{cases} \\ \tau_h^e &= \begin{cases} 1 - \frac{B(q)}{A} \frac{1-\gamma}{\alpha\gamma+1-\gamma} (xh^\theta)^{-\frac{\alpha\gamma}{(1-\gamma)(\alpha\gamma+1-\gamma)}} & \text{if } q \in (0, q^*(h, x)), \\ 0 & \text{if } q \geq q^*(h, x). \end{cases}\end{aligned}$$

The wedge $\tau_q^e \geq 0$ acts like a subsidy to saving, capturing the fact that whenever the capital constraint binds, an increase in saving today relaxes the constraint and increases profits tomorrow. That is, for constrained entrepreneurs, $\frac{\partial \Pi^c}{\partial q}(q, h, x) > 0$.

The wedge $\tau_h^e \in [0, 1]$ acts like a tax on the returns to schooling, capturing the fact that human capital is less productive for constrained entrepreneurs. This is because physical capital is lower, and complementary to human capital.

Notice that, relative to the economy without frictions, individual decisions in the economy with frictions are affected not only by the presence of distortions but also by general equilibrium price effects.

5.2.2 Production Wedges

We now recast the firm's problem as in [Hsieh and Klenow \(2009\)](#). We call it the proxy firm problem:

$$\Pi = \max_{k, l \geq 0} \left\{ (1 - \tau_a) p x (h^*)^\theta (k^\alpha l^{1-\alpha})^\gamma - (1 + \tau_k) (r + \delta) k - w l \right\}, \quad (\text{Pf})$$

where h^* is the human capital level that would emerge absent financial frictions (but still subject to the prices under frictions), and p is the output price, which may be normalized to 1 in our setup.

We label τ_a and τ_k individual-level *proxy wedges*, in the sense that they are generic wedges standing-in for the fundamental distortions affecting the economy. τ_a captures distortions along the potential revenue (i.e. revenue based on potential productivity $x(h^*)^\theta$) vs cost margin, whereas τ_k captures distortions along the capital vs labor input cost margin. Our task is now to infer proxy wedges from basic wedges. The proxy firm problem ([Pf'](#)) yields

the same solution as the original firm problem (Pf) when

$$1 - \tau_a = \left(\frac{h}{h^*} \right)^\theta$$

$$1 + \tau_k = 1 + \frac{\zeta}{r + \delta},$$

where ζ is the multiplier on the capital constraint.

It is possible to uncover an explicit mapping between proxy and basic distortions. Applying the Envelope theorem and using the definition of τ_q^e :

$$1 + \tau_k = 1 + \frac{\tau_q^e}{\lambda(r + \delta)}.$$

A mapping between τ_a and basic distortions obtains in closed form when $\psi = 0$. In this case $p_e = 1$ and, further assuming that the time constraint is slack, optimal schooling time s is proportional to expenditures e . Combining (31) and (32) under the constrained and the unconstrained cases, we obtain

$$1 - \tau_a = \left(\frac{1 - \tau_h^e}{1 + \tau_q^e} \right)^{\frac{\theta\xi}{1 - \xi\theta}},$$

where $\xi\theta < 1 - \gamma$ given our parametric assumptions.

These expressions allow us to interpret the two proxy wedges in terms of our financial frictions model. First, $\tau_k \geq 0$ amounts to a tax on capital. The reason is that the capital constraint increases the shadow rental price of capital. Second, $\tau_a \in [0, 1]$ amounts to a reduction in a firm's physical output. The reason is that the capital constraint decreases actual firm-level productivity xh^θ below potential, by discouraging entrepreneurial schooling investments. The total disincentive to investing in human capital is captured by the composite distortion $(1 - \tau_h^e)/(1 + \tau_q^e)$. This composite distortion amounts to a positive tax since (i) capital-constrained entrepreneurs run smaller firms, reducing the returns to investing in human capital, and (ii) for these households, accumulating wealth relaxes the capital constraint, and therefore commands a higher return compared to investing in human capital.

An alternative parametric case useful considering is for $\bar{l} = 0$ (and $\psi > 0$), assuming

again a slack time constraint. We obtain

$$1 - \tau_a = \left(\frac{1 - \tau_h^e}{1 + \tau_q^e} \right)^{\frac{1 - (\theta - \eta)\xi}{\theta\xi(1 - \gamma)}} \left(\frac{p_e^*}{p_e} \right)^{\frac{1 - (\theta - \eta)\xi}{\theta\xi(1 - \gamma)}}, \quad (33)$$

where p_e^* is the shadow unit price of schooling expenditures ignoring credit constraints. Although a closed form is not available, this formulation illustrates the role of schooling expenditure prices in amplifying the effect of the composite distortion on τ_a , especially for individuals with low learning ability z , or in countries with low \bar{z} . Recall from (25) that p_e equals one unit of the final good net of the increase in first-period earnings afforded by the additional human capital. Individuals with lower first-period earnings (lower z) tend to have higher p_e , and especially higher p_e^* . The higher p_e^*/p_e faced by these individuals captures the fact that schooling investments are particularly expensive for them, as they are less productive in generating first-period resources potentially available for building up collateral for the second-period entrepreneurial activity. This amplification mechanism is present in our general formulation, and will play a key role when comparing economies with different \bar{z} .

The production technology underlying the stand-in problem (P^f) is $y \equiv (1 - \tau_a) x (h^*)^\theta (k^\alpha l^{1-\alpha})^\gamma$. We follow Hsieh and Klenow (2009) in defining a firm's (actual) physical productivity $TFPQ$ and revenue productivity $TFPR$ as¹⁶

$$TFPQ \equiv \frac{y}{(k^\alpha l^{1-\alpha})^\gamma} = (1 - \tau_a) x (h^*)^\theta$$

$$TFPR \equiv \frac{py}{k^\alpha l^{1-\alpha}}.$$

¹⁶Notice that although the wedge τ_a looks similar to the revenue distortion τ_y of Hsieh and Klenow (2009), it plays a different role in our setting. Unlike τ_y in Hsieh and Klenow (2009), τ_a is a wedge between potential and actual physical productivity. It does not act as a pure revenue tax, representing instead the physical productivity effects of lower schooling investments. For this reason, τ_a is part of the definition of $TFPQ$, whereas τ_y would be part of the definition of $TFPR$, as in Hsieh and Klenow (2009). In terms of our model, in fact, there are no revenue distortions as defined by Hsieh and Klenow (2009).

The optimality conditions are

$$\begin{aligned}\gamma(1-\alpha)\left(\frac{k}{l}\right)^\alpha TFP R &= w \\ \gamma\alpha\left(\frac{k}{l}\right)^{\alpha-1} TFP R &= (1+\tau_k)(r+\delta),\end{aligned}$$

and so

$$\frac{k}{l} = \frac{\alpha}{1-\alpha} \frac{w}{(1+\tau_k)(r+\delta)}.$$

Revenue productivity is therefore

$$TFPR \propto (1+\tau_k)^\alpha.$$

Absent frictions, $\tau_q^e = \tau_h^e = 0$ and $e = e^*$. Therefore $\tau_a = \tau_k = 0$. In this case the distribution of $TFPR$ is degenerate, and the distribution of $TFPQ$ reflects only individual heterogeneity in abilities among households selecting into entrepreneurship. With frictions, we expect the distribution of $TFPR$ to become more dispersed, reflecting greater physical capital misallocation, and the distribution of $TFPQ$ to shift to the left, reflecting lower levels of entrepreneurial human capital for constrained entrepreneurs.

Figure 4 plots the distributions of $TFPR$ and $TFPQ$ in our model, for both the U.S. and the India (benchmark) calibrations. The degree of production misallocation in the economy with frictions is large. The standard deviation of $\log TFPR$ more than doubles from the U.S. to India. The mean of the $TFPQ$ distribution is 10% smaller in India, and is also more dispersed.

The next section will provide an explicit link between aggregate productivity and the moments of the $TFPR$ and $TFPQ$ distributions.

5.3 Misallocation and Aggregate Productivity

The final good sector admits an aggregate production function in our setting (see Appendix B):

$$Y = TFP (K^\alpha L^{1-\alpha})^\gamma,$$

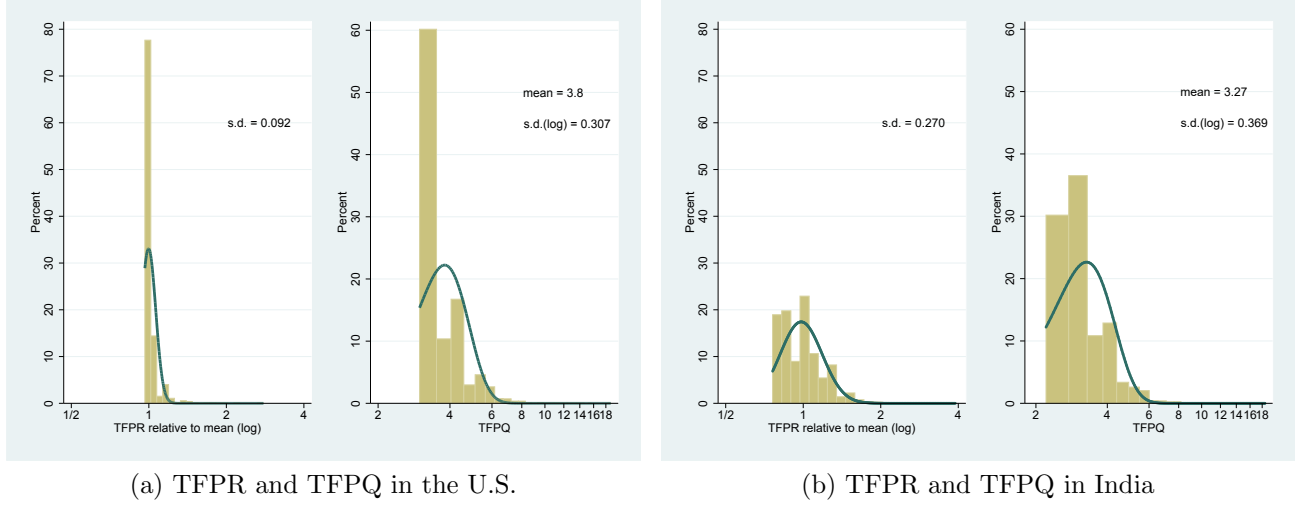


Figure 4: Revenue and physical productivity distributions

where $Y \equiv \int_B y d\Psi$, $K \equiv \int_B k d\Psi$, and $L \equiv \int_B l d\Psi$, and total factor productivity (TFP) is an aggregator of individual physical productivities and distortions

$$TFP \equiv \frac{\int_B \left(x(h^*)^\theta \frac{1-\tau_a}{(1+\tau_k)^{\alpha\gamma}} \right)^{\frac{1}{1-\gamma}} d\Psi}{\left[\int_B \left(x(h^*)^\theta \frac{1-\tau_a}{(1+\tau_k)^{1-\gamma+\alpha\gamma}} \right)^{\frac{1}{1-\gamma}} d\Psi \right]^{\alpha\gamma} \left[\int_B \left(x(h^*)^\theta \frac{1-\tau_a}{(1+\tau_k)^{\alpha\gamma}} \right)^{\frac{1}{1-\gamma}} d\Psi \right]^{(1-\alpha)\gamma}}.$$

Defining

$$TFPR' \equiv TFPR (1 + \tau_k)^{\alpha(\gamma-1)} \propto (1 + \tau_k)^{\alpha\gamma}$$

we can rewrite aggregate TFP as

$$TFP = \int_B \left(TFPQ \frac{\overline{TFPR}'}{TFPR'} \right)^{\frac{1}{1-\gamma}} d\Psi, \quad (34)$$

where \overline{TFPR}' is a geometric average of average marginal products of capital and labor.^{17,18}

¹⁷The presence of decreasing returns to scale in production ($\gamma < 1$) introduces a slight difference between $TFPR$ and the weights on $TFPQ$ in the expression for TFP , which we define as $TFPR'$. The two quantities behave very similarly though.

¹⁸ $\overline{TFPR}' \equiv \left\{ \left[\int_B \left(\frac{TFPQ}{\overline{TFPR}'} \right)^{\frac{1}{1-\gamma}} \frac{1}{1+\tau_k} d\Psi \right]^\alpha \left[\int_B \left(\frac{TFPQ}{\overline{TFPR}'} \right)^{\frac{1}{1-\gamma}} d\Psi \right]^{1-\alpha} \right\}^{\gamma(1-\gamma)} \kappa^{1-\gamma},$ with

Expression (34) is identical to the one obtained in Hsieh and Klenow's (2009) accounting framework. We extend their framework by considering distortions impacting firm-level physical productivity (τ_a).

To better understand the impact of distortions on aggregate TFP it is instructive to consider the case in which $x(h^*)^\theta$, $(1 - \tau_a)$, and $(1 + \tau_k)$ are jointly log-normally distributed among firms. The logarithm of aggregate TFP can then be written as a function of a few key moments of the joint distribution of firm-level wedges and potential productivities:

$$\log TFP = (1 - \gamma) \log ent + (1 - \gamma) \log E_B \left[TFPQ^{\frac{1}{1-\gamma}} \right] - \frac{1}{2} \frac{\alpha\gamma(1 - \gamma + \alpha\gamma)}{1 - \gamma} \text{var}_B(\log TFPR), \quad (35)$$

where $ent \equiv \int_B 1 d\Psi$ is the measure of the set of entrepreneur-households, and the expectation and the variance are conditional on the states in this set.

This expression is very similar to the one obtained by Hsieh and Klenow (2009), their equation (16), with two differences. First, since $\gamma = 1$ in their baseline case, the first term is absent. Second, and more importantly, in their case the $TFPQ$ distribution is exogenous. Here it is itself a function of the degree of financial frictions, through the response of schooling investments. This response entails an amplification of the aggregate productivity effects of financial frictions, which go beyond capital misallocation.

The first term in equation (35) is the TFP gain from specialization. Since firm-level technology exhibits decreasing returns to scale, aggregate productivity rises when output is produced by a larger number of smaller firms. The other two terms in equation (35) illustrate two channels through which firm-level distortions reduce the aggregate TFP. First, τ_a decreases the average firm-level physical productivity, by introducing a gap between potential actual ($TFPQ$) and potential physical productivities ($x(h^*)^\theta$). This effect is due to lower human capital investments by the entrepreneur-households in face of financial frictions. Second, dispersion in τ_k reduces aggregate TFP by introducing dispersion in marginal products of capital across firms, which is the effect traditionally emphasized by the misallocation literature.¹⁹

$\kappa \equiv \frac{1}{\gamma} \left(\frac{w}{1-\alpha} \right)^{1-\alpha} \left(\frac{r+\delta}{\alpha} \right)^\alpha.$

¹⁹Notice that, unlike $TFPQ$, the average level of $TFPR$ does not impact TFP . Intuitively, if all firms have the same gap between input prices and marginal products, aggregate productivity won't increase by

Decomposing further the second term in equation (35) allows us to identify five key moments that determine the total effect of financial frictions on aggregate TFP

$$\begin{aligned}
\log TFP = & \underbrace{(1 - \gamma) \log ent}_{\text{Specialization}} + \underbrace{(1 - \gamma) \log E_B \left[x (h^*)^{\frac{\theta}{1-\gamma}} \right]}_{\text{Potential productivity}} + \underbrace{(1 - \gamma) \log E_B \left[(1 - \tau_a)^{\frac{1}{1-\gamma}} \right]}_{\text{Schooling under-investment}} \\
& + \underbrace{\frac{1}{1 - \gamma} \text{cov}_B \left(\log \left(x (h^*)^{\theta} \right), \log (1 - \tau_a) \right)}_{\text{Schooling misallocation}} - \underbrace{\frac{1}{2} \frac{\alpha \gamma (1 - \gamma + \alpha \gamma)}{1 - \gamma} \text{var}_B (\log (1 + \tau_k))}_{\text{Capital misallocation}}.
\end{aligned} \tag{36}$$

The first and the last terms are once more the specialization gain and physical capital misallocation effects. The total effect on firm-level productivity $E_B \left[TFP Q^{\frac{1}{1-\gamma}} \right]$ is now decomposed into three components. The *potential productivity* term is determined by the selection of households into entrepreneurship, and thus by the misallocation of talent. In addition, it also reflects changes in entrepreneurial human capital investment due to changes in prices. The *schooling under-investment* term represents the effect of financial frictions on entrepreneur-household investments in human capital. As this term shows, the average level of schooling distortions τ_a matters for aggregate TFP.²⁰ The *schooling misallocation* term stems from the interaction between selection into entrepreneurship and human capital investments of entrepreneur-households. A negative covariance between $x (h^*)^{\theta}$ and $(1 - \tau_a)$ decreases aggregate TFP, since in this case entrepreneurs with the highest potential firm-level productivities face the largest distortions. In other words, the most talented entrepreneurs face the largest disincentive to invest in schooling, and therefore experience the largest productivity declines relative to potential.

5.4 Aggregate Consequences of Financial Frictions

We now consider the aggregate consequences of frictions in the model, for the U.S. and the two India calibrations, benchmark (when only λ differs from the U.S.) and schooling (when

reallocating a *given level* of aggregate capital across firms.

²⁰This contrasts with Hsieh and Klenow's (2009) framework, where only the dispersion and not the level of (revenue plus capital) distortions matters for aggregate TFP, to the extent that dispersion in wedges induces dispersion in marginal products.

also \bar{z} differs, in order to match average years of schooling in India). Table 2 looks at the implications for aggregate output, capital-output ratios, and aggregate TFP, both in the model and in the data. Our data source is version 8.1 of the Penn World Tables (Feenstra *et al.*, 2013). Appendix C describes in detail the mapping of the aggregate production function between model and data.

| | Y | | K/Y | | TFP | |
|---------------|-------|------|-------|------|-------|------|
| | Model | Data | Model | Data | Model | Data |
| U.S. | 1.00 | 1.00 | 2.21 | 2.99 | 1.00 | 1.00 |
| India - bench | 0.80 | | 1.87 | | 0.84 | |
| - school | 0.07 | 0.08 | 1.95 | 1.93 | 0.57 | 0.26 |

Table 2: Macroeconomic aggregates

The model produces significant differences in these macroeconomic aggregates. The magnitudes are smaller than what we see in the data for the benchmark (‘bench’) calibration, but very close for the schooling (‘school’) calibration. Namely, under the benchmark calibration, the model accounts for 22% of the 74 percent India-U.S. TFP difference, and for 22% of the 92 percent aggregate output difference. Under the schooling calibration, it accounts for 58% of the TFP difference, and generates an output difference as large as in the data.²¹

Table 3 provides a decomposition of the TFP difference in line with equation (36). As discussed previously, this decomposition is valid under a joint log-normality assumption. This appears to be a good approximation, based on the fact that, as the bottom of Table 3 shows, the actual TFP difference (from Table 2) are reasonably close to the TFP difference implied by equation (36).

According to this decomposition, the *specialization* term contributes negatively to the U.S.-India TFP difference, since the entrepreneurship rate is higher in India. The other two terms, *firm-level productivity* and *physical capital misallocation*, contribute each to about a 10% TFP difference under the benchmark calibration. The contribution of *firm-level productivity* is further decomposed into three terms. *Potential productivity* is on average higher

²¹The reason the latter calibration delivers output differences in line with the data in spite of lower TFP differences is that human capital stock differences turn out to be larger than the PWT8.1 estimates we rely upon to compute TFP - see Appendix C - even if we do match average schooling years differences.

in India, since input prices are lower, in spite of a worse ability selection into entrepreneurship. Lower input prices give incentives for unconstrained entrepreneurs to expand further their production scale, and hence invest more in education. A lower interest also encourages entrepreneurs to invest more in education, for given production scale. This term therefore contributes negatively to the model’s U.S.-India TFP difference. However, *schooling under-investment* is more important in India, contributing to a 5.2% loss in TFP relative to the U.S. Finally, there is also a significantly higher degree of *schooling misallocation* in India compared to the U.S. The most talented entrepreneurs in India are the ones cutting back the most in terms of education, and this effect entails a 4% TFP loss.

The firm-level productivity effect is significantly larger under the schooling calibration, accounting in this case for a 46% TFP loss in India. One of the main effects, not surprisingly, comes from what is now a 22% loss in potential productivity. This is due to the direct productivity effect of a lower \bar{z} , compounded by lower schooling investments absent frictions. The most interesting outcome is that frictions now play a much more significant role. Schooling under-investment contributes to a TFP loss which is more than twice as large, and schooling misallocation now entails a 21% TFP loss compared to the U.S.

The intuition behind these larger effects can be traced back to the discussion surrounding (33). The productivity of human capital investments in India is on average lower under the schooling calibration. This effectively weakens the self-financing channel for future entrepreneurs, by lowering their first-period wage earnings. For given basic distortions, stemming from the presence of financial frictions, a lower ability to raise first-period earnings makes schooling investments more expensive. This mechanism amplifies schooling under-investments in India, and generates individual-level productivity distortions τ_a which are higher on average, as well as more dispersed across individuals.

Table 4 focuses on a few key micro-level features underlying production. It displays the rate of entrepreneurship and the average firm size (relative to the U.S).

The rate of entrepreneurship in the U.S. comes again from Levine and Rubinstein (2015), see Section 4. For India, we rely on the information provided in Table 6 of Mitra and Verick (2013). They report a rate of self-employment for males aged 15-59 ranging from 41 percent in urban settings to 53 percent in rural settings (years 2009-10). We focus on the average of

| <i>TFP</i> term | % Loss India relative to U.S. | |
|--------------------------------|-------------------------------|--------|
| | bench | school |
| Specialization | −0.072 | −0.076 |
| Firm-level productivity | +0.093 | +0.463 |
| Potential productivity | −0.004 | +0.222 |
| Schooling under-investment | +0.052 | +0.131 |
| Schooling misallocation | +0.039 | +0.206 |
| Physical capital misallocation | +0.103 | +0.092 |
| Approximate <i>TFP</i> | 0.127 | 0.476 |
| Actual <i>TFP</i> | 0.161 | 0.428 |

Table 3: Aggregate TFP loss decomposition

the two.

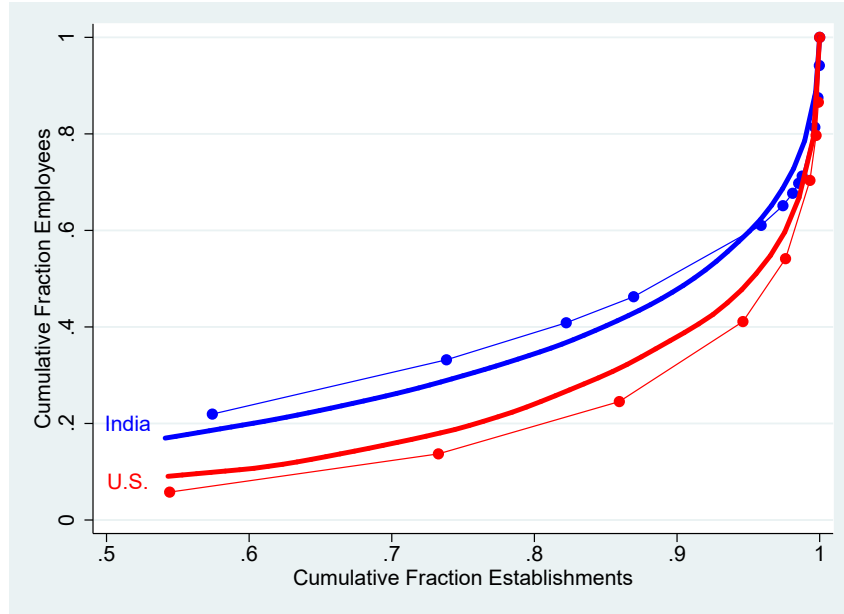


Figure 5: Lorenz curves, model (straight line) vs data (dotted line)

In the data, our measure of size is the number of employees.²² Once again, we take the data counterpart of an entrepreneurial firm in the model to be an establishment. For the U.S., the evidence comes from [Henly and Sanchez \(2009\)](#), based on the Census Bureau’s 2006 County Business Pattern Series. They report an average of 15 employees per establishment

²²We use the total firm-level labor input as the model counterpart. Unfortunately our model does not distinguish between the number of workers and the quantity of human capital employed. To partially address this issue, we equate the number of workers employed by a firm to l/\bar{h}^w , where \bar{h}^w is the average level of human capital per worker in the whole economy.

| | ent.rate | | avg. firm size | |
|---------------|----------|-------|----------------|------|
| | Model | Data | Model | Data |
| U.S. | 0.050 | 0.096 | 1.00 | 1.00 |
| India - bench | 0.080 | 0.470 | 0.73 | 0.29 |
| - school | 0.082 | | 0.16 | |

Table 4: Entrepreneurship rate and average firm size

across all sectors of activity (their Figure 1). For India, we rely on the Fifth Economic Census by the Indian Ministry of Statistics and Program Implementation, which concerns the year 2015.²³ The data is available for all sectors of activity across all Indian states, in both urban and rural settings. It provides the same type of information (i.e. establishment and worker counts by establishment size groups) as the County Business Pattern Series in the U.S. This allows us to apply the same method as [Henly and Sanchez \(2009\)](#) to obtain approximations to the relevant moments of the size distribution in India from the establishment and worker counts, and ensures comparability across the two countries.²⁴ We obtain an average of 4.38 employees per establishment in India, which implies a India-U.S. ratio of 0.29 in the data.

Consistently with the data, our model generates more entrepreneurs in India, operating on average at a smaller scale. The main mechanism driving the higher rate of entrepreneurship is the drop in input prices, which encourages lower ability individuals to engage in production. The magnitude is much lower than the one we obtain from the data.

The establishment-size distribution, both in the model and in the data, not only gets shifted to the left in India, but also develops a more pronounced right skew: there is a larger mass of very small firms in India. This pattern is illustrated in Figure 5 for the benchmark calibration.²⁵ As in the data, the smaller firms in India account for a larger fraction of aggregate employment compared to the U.S. Overall, the model delivers firm-size distribution differences which are consistent with the data, however the magnitudes are smaller in the model. The model accounts for about one half of the 2/3 India-U.S.

²³Freely available at <http://mospi.nic.in>.

²⁴The mean establishment size can be calculated exactly from the establishment and worker counts. Higher-order moments can be approximated by assuming a triangular distribution for the establishments inside each size group. See [Henly and Sanchez \(2009\)](#).

²⁵The Lorenz curves under the schooling calibration are qualitatively similar, however the gap between model and data is larger.

| | aggregate | | workers | | entrepreneurs | |
|---------------|-----------|-------|---------|-------|---------------|-------|
| | Model | Data | Model | Data | Model | Data |
| U.S. | 14.16 | 13.70 | 14.21 | 13.70 | 13.60 | 13.90 |
| India - bench | 13.59 | 5.26 | 13.61 | — | 13.41 | — |
| - school | 5.26 | | 5.41 | | 3.61 | |

Table 5: Schooling

difference in average firm size under the benchmark calibration, which gets overstated under the schooling calibration.

Table 5 looks at average years of schooling. The U.S. data, both aggregate and by occupation, are averages over 1996-2012 from the Current Population Survey as reported by [Levine and Rubinstein \(2015\)](#). The Indian data is unfortunately only available for the aggregate, and comes from [Barro and Lee \(2013\)](#). We use the reported average years of schooling of the population older than 15 years over 1995-2010.

The model produces lower schooling levels in India independent of occupation, however the magnitude is significantly lower than in the data under the benchmark calibration. One reason the model is unable to deliver a larger effect is that the interest rate is lower in India, which gives incentive for larger schooling investments in this country both among workers and entrepreneurs.

The schooling calibration matches the average years of schooling in India by design, and therefore produces much larger schooling responses across occupations as well. The effect is more pronounced across entrepreneurs, highlighting the central mechanism of our model.

6 Concluding Remarks

We investigate the aggregate productivity effects of financial frictions, in an environment where frictions impact both firm-level investment decisions, and household-level schooling decisions. We show that, in anticipation of the effect credit constraints have on their future business activity, entrepreneurs under-invest in schooling. Further, this behavior is more pronounced among the most able entrepreneurs, generating a misallocation of schooling investments. Both effects are shown to produce important aggregate productivity losses.

We are able to account for about $1/5$ of the U.S.-India aggregate productivity difference, of which half is due to these effects. A calibration that matches the U.S.-India difference in average years of schooling significantly amplifies the impact of financial frictions. In this case the model accounts for 58% of the TFP differences.

A Profit Functions

The profit functions are:

$$\begin{aligned}\Pi^*(h, x) &= A (xh^\theta)^{\frac{1}{1-\gamma}}, \\ \Pi^c(q, h, x) &= B(q) (xh^\theta)^{\frac{1}{1-(1-\alpha)\gamma}} - (r + \delta) \lambda q,\end{aligned}$$

where

$$\begin{aligned}A &= \left[A_0 \left(\frac{(1-\alpha)(r+\delta)}{\alpha w} \right)^{1-\alpha} \right]^\gamma (1-\gamma), \\ A_0 &= \left[\frac{(1-\alpha)(r+\delta)^{1-\frac{1}{(1-\alpha)\gamma}}}{\alpha w} \right]^{(1-\alpha)\frac{\gamma}{1-\gamma}} (\alpha\gamma)^{\frac{1}{1-\gamma}}, \\ B(q) &= B_0 (q^{\alpha\gamma})^{\frac{1}{1-(1-\alpha)\gamma}}, \\ B_0 &= \frac{1-(1-\alpha)\gamma}{(1-\alpha)\gamma} w \left[\frac{(1-\alpha)\gamma\lambda^{\alpha\gamma}}{w} \right]^{\frac{1}{1-(1-\alpha)\gamma}}.\end{aligned}$$

B Aggregation

The individual input demands from problem (P^{f'}) can be written as

$$\begin{aligned}l &= \frac{\left[x (h^*)^\theta \frac{1-\tau_a}{(1+\tau_k)^{\alpha\gamma}} \right]^{\frac{1}{1-\gamma}}}{\int_B \left[x (h^*)^\theta \frac{1-\tau_a}{(1+\tau_k)^{\alpha\gamma}} \right]^{\frac{1}{1-\gamma}} d\Psi} L \equiv \varpi_l L \\ k &= \frac{\left[x (h^*)^\theta \frac{1-\tau_a}{(1+\tau_k)^{1-\gamma(1-\alpha)}} \right]^{\frac{1}{1-\gamma}}}{\int_B \left[x (h^*)^\theta \frac{1-\tau_a}{(1+\tau_k)^{1-\gamma(1-\alpha)}} \right]^{\frac{1}{1-\gamma}} d\Psi} K \equiv \varpi_k K.\end{aligned}$$

Aggregate production is then

$$\begin{aligned}
Y &= \int_B y d\Psi \\
&= \int_B (1 - \tau_a) x (h^*)^\theta (k^\alpha l^{1-\alpha})^\gamma d\Psi \\
&= TFP (K^\alpha L^{1-\alpha})^\gamma
\end{aligned}$$

where

$$TFP \equiv \int_B (1 - \tau_a) x (h^*)^\theta \varpi_k^{\alpha\gamma} \varpi_l^{(1-\alpha)\gamma} d\Psi.$$

C Mapping Between Model and Data

The aggregate production function in the data is

$$Y = TFP (K^\alpha L^{1-\alpha})^\gamma,$$

where $L \equiv h\ell N$ is the total labor input, with h being human capital per worker, ℓ the total number of workers per engaged person, and N the number of engaged persons (which includes workers and the self-employed).

We proceed in a way analogous to the related literature employing decreasing returns to scale technology (e.g. [Buera and Shin, 2013](#)) and abstract from scale effects. That is, we treat the data as if $N = 1$ for both the U.S. and India, and rewrite the aggregate production function in terms of (lowercase) variables per engaged person as

$$y = TFP (k^\alpha (h\ell)^{1-\alpha})^\gamma.$$

We rely on PWT8.1 data in order to back out TFP for the U.S. and India. We use data for the year 2005 on current-year PPP-adjusted GDP per engaged person (variable $CGDP^o$ divided by EMP), capital stock per engaged person (CK/EMP), and human capital stock per engaged person (variable HC), together with our parameter values for α and γ . Human capital stocks result from mapping average years of schooling from [Barro and Lee \(1993\)](#)

through an exponential human capital technology specification as in [Caselli \(2005\)](#), using returns to schooling specific to each schooling level.

We assume that human capital per worker h , which we do not observe in PWT8.1, equals human capital per engaged person. The total labor input $h\ell$ is then computed by equating ℓ to one minus the rate of entrepreneurship from [Table 4](#).

D Numerical Algorithm

We solve the model using value function iteration.

1. **Discretization:** Discretize ω into $\{\omega_0, \dots, \omega_{N_\omega}\}$. We choose the upper bound and lower bounds such that increasing them further apart has a negligible effect on the solution.

The VAR(1) process for abilities is discretized into a Markov chain using the procedure described in [Tauchen and Hussey \(1991\)](#).

2. **Occupational choice and production:** Solve for $\omega'(q, h, x)$ given the current guess for prices w and r .

- (i) Compute the threshold level of saving $q^*(h, x)$.
- (ii) Compute profits $\Pi(q, h, x)$.
- (iii) Compute next generation's wealth $\omega'(q, h, x)$.

3. **Saving and education:** Solve for the decision rules $e(\omega, z, x)$, $s(\omega, z, x)$, and $q(\omega, z, x)$, given $\omega'(q, h, x)$ from [step 2](#), and given the current guess for prices.

- (i) Guess value function $V^j(\omega, z, x)$ at gridpoints.
- (ii) Solve for the right-hand-side of the Bellman equation:

$$V^{j+1}(\omega, z, x) = \max_{c, e, s, q} \left\{ u(c) + \beta \sum_{z', x'} \pi(z', x' | z, x) V^j(\omega'(q, h, x), z', x') \right\}$$

subject to [\(4\)](#)-[\(6\)](#).

First try an interior solution for q . If $q \geq -\lambda\phi\omega$ then the solution has been found. Otherwise set $q = -\lambda\phi\omega$ and find s and e subject to this constraint. V^j is approximated by a piecewise linear function for future wealth levels outside of the grid.

(iii) Iterate until $V^j(\omega, z, x) \approx V^{j+1}(\omega, z, x)$.

4. **Invariant distribution:** Approximate by simulating a large cross-section of $N + 1$ agents over a sufficiently large number of T periods. Decision rules are linearly interpolated over a very fine grid.
5. **Market clearing:** Check whether the labor and capital markets clear. Compute excess demand for labor and capital from the invariant distribution as:

$$EDL(w, r) = \frac{1}{N} \sum_{n=2}^{N+1} [\mathbb{1}_{n-1} l_{n-1} + s_n \bar{l} - (1 - \mathbb{1}_{n-1}) h_{n-1} - (1 - s_n) \psi h_n]$$

$$EDK(w, r) = \frac{1}{N} \sum_{n=2}^{N+1} \left[\mathbb{1}_{n-1} k_{n-1} - \frac{q_n}{1+r} \right],$$

where $\mathbb{1}_n$ is an indicator which takes the value of 1 if household n chooses entrepreneurship and 0 otherwise. Iterate on market prices until $EDL(w, r) \approx 0$ and $EDK(w, r) \approx 0$.

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