Finance and Development: A Tale of Two Sectors*

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Abstract

In poor countries, total factor productivity (TFP) is particularly low in sectors producing tradable goods, and relative prices of tradables are high. We document that an important difference between tradable and non-tradable sectors is their average establishment size: tradable establishments operate at much larger scales. We develop a model co-determining TFP, relative prices and scales across industrial sectors. In our model, financial frictions disproportionately affect TFP in tradable sectors where production requires large setup costs. Our quantitative exercises show that financial frictions explain 50% of the observed cross-country patterns of TFP, relative prices and relative scales across sectors.

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"It was the best of times, it was the worst of times, it was the age of wisdom, it was the age of foolishness, it was the epoch of belief, it was the epoch of incredulity, it was the season of Light, it was the season of Darkness, it was the spring of hope, it was the winter of despair..." Dickens (1859), p.1

"England and France, which in terms of the level of development and technology were roughly comparable at the middle of the eighteenth century ... went through radically different paths of development. England went on to develop and benefit hugely from the factory system and large-scale production, whereas France remained a nation of small farms and cottage industries for the next hundred years." Banerjee and Newman (1993), p.292

1 Introduction

Income per capita differences across countries are mainly accounted for by lower TFP in poor countries (Klenow and Rodriguez-Clare, 1997, Hall and Jones, 1999). More disaggregated data show that the TFP gap between rich and poor countries differs systematically across sectors in the economy: Poor countries are particularly unproductive in producing tradables.[1] Since equipment is tradable, low relative productivity in tradables increases the relative price of equipment in poor countries and limits capital accumulation in poor countries.[2] Thus, an important task in development economics is to understand the causes of such sectoral differences in TFP.

In this paper, we propose and quantify a theory of sectoral productivity differences based on sectoral differences in optimal scale of establishments, and on cross-country differences in financial developments.

We start from the observation that the size of a typical establishment, measured by

[1] Balassa (1964) and Samuelson (1964) are the classic citations for tradables and non tradables. Hsieh and Klenow (2007) and Herrendorf and Valentinyi (2007a) are more recent contributions.

[2] See again, Hsieh and Klenow (2007), Eaton and Kortum (2001), and Jones (1994).

workers per establishment, reflects the technological differences across industrial sectors. Using detailed sectoral data, we document that the average establishment in the tradable sector is three times larger than that in the non-tradable sector. Furthermore, using price data for a cross section of countries, we show that at a disaggregate level, poor countries are relatively unproductive in industries with larger scales.

These observations lead us to study models that imply sectoral scale differences, and to explore how financial frictions distort scales of operation in different sectors.

We model production in which entrepreneurs face a one-time setup cost to start an establishment. Entrepreneurs have a limited span of control, and establishments operate diminishing-returns technologies. Sectors differ in their setup costs, and hence their profit-maximizing scale: Tradable sectors have large setup cost, and hence operate at large scale. Agents choose sectors and occupations. In a frictionless economy, the most able individuals become entrepreneurs and the marginal products of capital is equalized across sectors and establishments. With financial frictions—which we model with endogenous enforcement constraints—entrepreneurs' investment decisions are constrained by their available wealth. The decisions of whether to become an entrepreneur, in which sector, and how much capital to invest are driven not only by ability but also wealth. Tighter financial frictions hurt productivity, and disproportionately so in the large-scale tradable sector.

Credit market imperfections are a natural candidate for distortions disproportionately affecting large-scale sectors. A central role of credit markets is precisely to provide the financing that is critical for the viability of large-scale ventures with significant setup costs. Indeed, it has been widely recognized that well-functioning credit markets are an important institution missing from poor economies[3], and a large theoretical literature has considered the role of credit markets in economic development.

Our quantitative exercises show that financial frictions help explain the observed patterns

[3] The literature here is vast. Banerjee and Duflo (2005) provide an excellent review. Banerjee and Duflo (2004) and Kaboski and Townsend (2007) provide model-based, quasi-experimental evidence of credit constraints. Townsend (forthcoming) gives an in depth case study of Thailand.

in relative TFP and relative prices of tradable (large scale) v. non-tradable (small-scale) goods. The model explains roughly half of the relative price and income relationship. In addition, financial frictions lower overall output and wages. At the same time, they increase the number of establishments in the small-scale sector, and decrease that in the large-scale sector, because of selection of low wealth individuals away from the high scale sector, and also away from being workers. Finally, the relative size of establishments in the large-scale sector increases with the degree of financial frictions, and we present suggestive evidence in favor of this testable implication.

The paper is most closely related and complementary to two others in the literature that emphasize the differential effects of financial frictions on manufacturing industries.[4] Rajan and Zingales (1998), an empirical paper, creates an index of dependence on external sources of financing for each industry and test whether industries that are particularly dependent on financing grow relatively faster in countries with strong financial systems. Erosa and Hidalgo (forthcoming) is a theoretical paper showing how financial frictions have differential effects on productivity in manufacturing industries with different fixed cost requirements. Our paper differs from these in three ways. First, our analysis explicitly combines data and theory by quantifying the effect of financial development on sectoral productivity. Second, we introduce scale as an empirical measure related to setup costs and financing. Finally, we broaden the analysis to encompass the tradable and non-tradable sectors, and emphasize their scale differences.

The next section documents the key facts that motivate our analysis. Section 3 develops the model, and calibrates the model with no credit constraints. Section 4 presents the quantitative experiments and contrast the implication of the theory to detailed sectoral size distribution data of the US, Mexico and the SSIS panel. Section 5 concludes.

[4]This paper also contributes to a vast literature relating financial frictions and entrepreneurship to development, including: Aghion and Bolton (1997), Banerjee and Newman (1991),Buera and Shin (2007), Castro, Clemente and Mcdonald (2007), Lloyd-Ellis and Burnhardt (2001),

2 Facts

This section documents the key facts in our study. First, we revisit the Balassa-Samuelson fact of the positive relationship between relative productivity in tradables and output per worker. Second, we show that a similar relationship holds between relative productivity and financial development. Third, we identify scale as a primary distinction in technologies between sectors. Finally, we show at a disaggregated level, that the relative price-income relationship is related to scale.

2.1 Relative Productivity and Development

The Balassa-Samuelson fact is that, in poor countries, the prices of tradables are high relative to those of non-tradables. Figure 1 confirms this fact for the 1996 ICP benchmark by plotting the relative price of tradables against real output per worker from the Penn World Tables 6.2.[5] Here the relative price is produced by creating Geary-Khamis aggregated prices for tradables and nontradables sectors using 27 disaggregated product categories.[6] The relative price of tradables has a strong negative relationship with log output per worker. The regression elasticity of -0.37 is highly significant at the one percent level, and the relationship has an R^2 of 0.42.

This relationship can be interpreted as reflecting a lower total factor productivity in tradables relative to non-tradables in poor countries. Indeed, in models with constant returns to scale aggregate production functions, and equal factor shares across sectors, these relative prices equal the inverse of relative TFP.[7] Differences in factor shares and the relative supply

[5] There are 115 ICP benchmark countries in 1996. For the sake of maintaining a consistent sample, we present results based on the 102 countries for which we have data on financial development from Beck et al (2000). The results using all 115 countries are virtually identical.

[6] The tradable categories consist of clothing, 9 food and beverage categories, footwear, fuel, furniture/floor coverings, household appliances, household textiles and other household goods, machinery/equipment, tobacco, and transportation equipment. The non-tradables consist of communication, construction, education, medical/health, recreation/culture, rent and water, restaurants/hotels, and transportation services. We do not classify four final goods price categories: "changes in stocks", "collective consumption by government", "net foreign balance", and "other goods and services".

[7] See, for example, Hsieh and Klenow (2007) who use this relationship to identify aggregate distortions

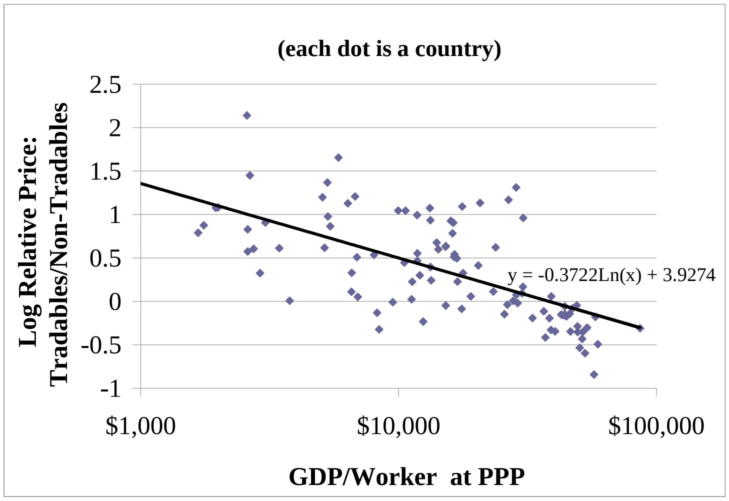

Figure 1: GDP/Worker

of factors (e.g., higher levels of physical capital or human capital per worker) could break this inverse relationship, but empirically factor shares do not vary greatly across sectors, and if anything, the non-tradable sector tends to be intensive in human and physical capital.[8] Explaining the source of this relative TFP vs. output per worker relationship is the goal of the paper.

2.2 Relative Productivity and Financial Development

Financial development is a potential suspect for explaining cross-country differences in relative productivity. A common measure of a country's level of financial development is its ratio of external financing (private credit+private bond market capitalization+stock market capitalization) to GDP (LaPorta et al, 1998, Rajan and Zingales, 1998). Figure 2 presents the ICP data of log relative prices vs. the ratio of external financing to GDP taken from Beck et al (2000). The relationship is quite similar with a slightly lower estimated elasticity of 0.32, but a slightly higher R^2 of 0.42.

Given the similarities between the relationships, *a priori* financial development has poten-

between capital and labor and sectoral TFP differences.

[8]See Herrendorf and Valentinyi (2007b) for physical capital and Buera and Kaboski (2007a) for human capital.

tial to explain the Balassa-Samuelson fact. In the theory, we present financial development will be the causal force, however. A simple joint regression of log relative prices on both log GDP/worker and log external financing/GDP gives suggestive evidence. In this joint regression, the elasticity with respect to external financing (0.23) is 50 percent higher than the coefficient with respect to output per worker (0.16) with a substantially smaller standard error.[9]

2.3 Scale Differences Across Sectors

To identify a reason for financial development having a differential effect on sectors, we consider a deep technological distinction between the tradable and non-tradable sectors of the economy: the difference in the scale of technologies. Two empirical proxies are used for the scale of technologies: workers per establishment and workers per enterprise. Establishments are locations of business, so that a single enterprise, Walmart, for example, may have multiple establishments.[10]

Table 1 presents measures of average scale across broad final goods sectors of the U.S. economy[11]. The first two columns are based on 2002 data from the OECD Structural Statistics for Industry and Services (SSIS) database. These data are useful because they provide both establishment and enterprise data in a comparable ISIC 3.2 4-digit classification which can used for comparison across OECD countries. The third column is based on data from the 2002 U.S. economic census, which is on an establishment basis using the NAICS 8-digit classification.[12] We present unweighted averages, the measure of interest implied by implied

[9] Measurement error in either output per worker or financial development could confound these estimates, to the extent that one is a mismeasured proxy for the other.

[10] The different data sources also include two different measures of workers: number of employees and total number of persons engaged. The major difference is that the latter includes proprietors, while the former may includes some types of temporary or contract workers. For some countries, we have both measures, and the two mirror eachother well.

[11] These sectors are constructed to reflect final goods categories covered in the ICP data. Manufacturing consumption includes food, beverages, textiles, clothing, medicine, furniture, appliances, TVs and radios, cars, household items, and media. Equipment includes all manufactured equipment not included in consumption. Together, these two encompass tradables. Services includes accomodation/food services, arts/entertainment, communication, education, FIRE, health, retail, sewage, transportation, and wholesale.

[12] There are also subtle differences in definitions of workers across the two samples. In particular, the SSIS

by the model we present, but worker-weighted averages show similar patterns.

	OECD SSIS Data		U.S. Census Data
	Workers per Estab.	Workers per Enterp.	Workers per Estab.
Manuf. Cons. (m)	33	37	42
Services (s)	9	18	16
Equip. Invest. (e)	56	62	81
Const. Invest. (c)	13	9	10
Tradables (m+e)	43	48	48
Non-tradables (s+c)	12	15	15

Table 1: Scale by Sector, U.S.[13]

Whether establishment or enterprise is used as the unit of measure, average scale varies considerably across these broad sectors of the U.S. economy. The top breaks out scale by disaggregated sectors: manufactured consumption, services, equipment investment, and construction. Manufactured consumption and equipment investment tend to be large scale, while services and construction are smaller scale. This distinction is precisely the tradable vs. non-tradable distinction in the two rows below.[14] Hence, the tradable sector is substantially larger scale than the non-tradable sector. In the SSIS data for workers per establishment, the tradable sector is over 3.5 times as large (43 vs. 12). The ratio of tradable scale to non-tradable scale is smaller using enterprise as the unit, but still over 3 (48 vs. 15). Finally, the U.S. census establishment data, yields larger numbers for scale, but the ratio is still above 3 (again 48 vs. 15).[15]

data measures "number of persons engaged", which includes proprietors. The census data is "number of employees" and excludes proprietors.

[13] The averages are unweighted averages across 4-digit industries (OECD SSIS data) and 8-digit industries in the U.S. census data. One source of the larger values for the U.S. census data come from the fact that air transportation and rail transportation have been dropped from the SSIS data to assist cross-country comparison.

[14] We lack comparable scale data for agriculture, a third component of tradables. In advanced economies, land/capital investments per farm are substantial, but workers/farm may not be large.

[15] Buera and Kaboski (2007b) build on the related scale distinction between manufacturing and services.

In the model we develop in the next section, differences in scale will be driven by differences in set-up costs across sectors. We view these costs as the costs of setting up and learning to operate a particular technology. Given this interpretation, establishment is our preferred unit of reference because we think it more often reflects the technology of production, but for some technologies (e.g., Walmart), these costs may be at the firm level.

2.4 Relative Prices and Scale

In the United States, where capital markets are relatively well-functioning, we view the observed scale of technologies as closely mirroring the optimal scales of different technologies.[16] A natural question to ask is how the relative prices relate to the scale of technologies. We ran cross-country regressions of the prices of disaggregated ICP price data (relative to country PPP) on log output per worker for each category:

$$\log \frac{p_{i,s}}{PPP_i} = \alpha + \beta_s \log(\text{real GDP/WOK}_i) + \varepsilon_{i,s}$$

where $p_{i,s}$ is the 1996 price of sector s in country i, PPP_i is the 1996 PPP price level of country i, and real GDP/WOK$_i$ is the output per worker in 1996 international prices.

Categories with highly negative coefficients are categories whose relative prices fall markedly with output per capita (as with the tradable sector). We then mapped these disaggregated ICP categories into measures of scale using the U.S. Economic Census data.[17]

Figure 2 presents the pattern between these estimated coefficients from the price regressions β_s (vertical axis) and workers per establishment (logarithmic horizontal axis). The data trend downward with a coefficient of -0.15, again significant at the 1 percent level. Thus, the larger scale categories are those that behave most similarly to tradables; their relative prices decrease the most with output per worker. Realizing the implications for TFP, relative TFP

[16] At a disaggregated level, there is a high correlation between the scale in the United States and the scale in other countries. We return to this pattern in Section 4.

[17] This mapping is limited by our lack of data on agriculture, so only the scale of food manufacturing establishments could be used. It is at least comforting that none of the food categories appear to be outliers.

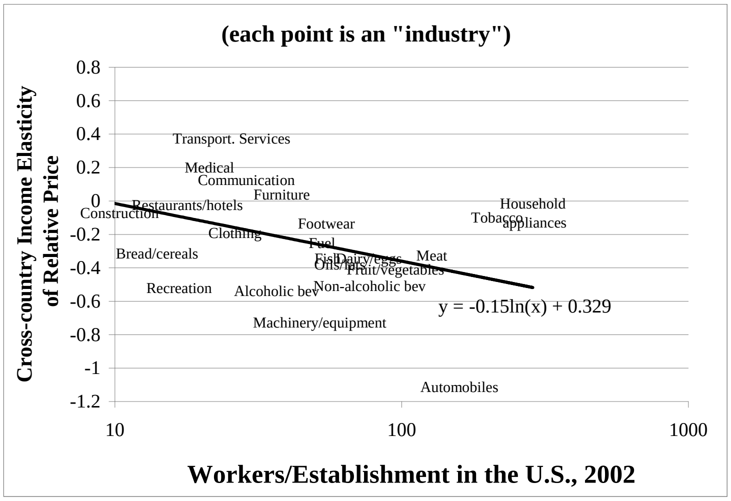

Figure 2: Cross-Country Relative Price Elasticity vs. Scale

for these large scale technologies increases the most with output per worker.

Why might poor countries be particularly unproductive in operating technologies with large optimal scales? Again, to the extent that scale reflects large set-up costs, we view scale as being related to financial dependence.[18] A final fact, which has been well-documented in other existing papers, is that poor countries tend to have lower levels of financial intermediation and lower levels of investor protection (see King and Levine, 1993, and LaPorta et al,1998). The next section develops a model to potentially explain these patterns based on poor countries having tighter credit constraints.

3 Model

We model an economy with two sectors, $s = NT$ (small-scale, non-tradable sector),T (large-scale, tradable sector); and, in each sector, two occupations (worker and entrepreneur/manager). The economy is open and takes the price of tradables as fixed; in the end,

[18] Indeed, our model is based on a different measure of financial dependence than Ranjan and Zingales (1998), since the set up cost in our model measures absolute need, while they measure the fraction of investment that is externally financed. The two are nonetheless related; for the manufacturing industries they consider, log average workers/establishment is positively related to their financial dependence index for young firms, and mildly significant at the 6 percent level.

with only one tradable good, openness will simply set the price of the tradable output. There is a continuum of dynasties. At the beginning of a "generation", dynasties only differ in terms of their wealth (a). At that time, individuals make an irreversible decision to specialize in a particular sector. After choosing a sector, they draw a sector-specific entrepreneurial idea z from the distribution $\mu(z)$. Agents then decide whether to work for a wage or start a business in their sector. Entrepreneurial ideas die with probability $1-\gamma$, in which case, a new "generation" within a dynasty again gets to choose sectors and draw a new entrepreneurial ability.[19]

3.1 Preferences

Dynasties preferences are described by the following expected utility function over sequences of pairs of sectoral consumption $c_t = (c_{NT,t}, c_{T,t})$,

$$U(c) = E\left[\sum_{t=0}^{\infty} u(c_t)\right]$$

where $u(c_t) = \frac{1}{1-\sigma}\left(c_{NT}^{1-\varepsilon} + c_T^{1-\varepsilon}\right)^{\frac{1-\sigma}{1-\varepsilon}}$.

The expectation is over the realization of the draw of entrepreneurial ideas (z) and the death of these ideas.

3.2 Occupational Choice and Technology

Individuals from a new generation starting with wealth a must first decide the sector in which to specialize. This assumption captures, in a very simplified way, the fact that individuals obtain sector-specific skills early in their careers that may allow them to manage a technology (Chari and Hopenhayn, 1993).[20] To reduce the dimensionality of the problem, we collapse

[19] This can be due to the fact that the current generation dies and is replaced by someone that does not share the same talent, or due to the fact that the "market conditions" change making the skill of the current generation obsolete.

[20] This assumption captures also the idea that many new firms is a sector are started by former employees of firms in this sectors, i.e., spin-offs. See Franco and Filson (forthcoming) for a model of spin-offs along

this initial training period into an infinitesimal moment.

After drawing the sector-specific productivity z associated with their entrepreneurial idea, individuals choose whether to work for a wage or start a business in sector s. If they choose to work for a wage, they can do it in either of the sectors. This assumption guarantees that there is a single labor market with wage w.

Alternatively, agents can start a business in the sector where they specialized. To start a business, they must pay a fixed setup cost of κ_s units of the sector's output. The crucial assumption is that $\kappa_T > \kappa_{NT}$. After paying the setup cost, they produce using capital (k) and labor (l) according to the following production function:

$$zf(k,l) = zk^{\alpha}l^{\theta}$$

Per-period profits of an entrepreneur operating in sector s are:

$$\pi(k,l;r,w) = p_s zk^{\alpha}l^{\theta} - Rk - wl$$

The value of being a worker $v^w(a,z,s)$ depends on an agent's assets a, but also the productivity z and sector s of an agent's idea which may be implemented at a later date. The value of being an entrepreneur $v^e(a,z,s,b)$ depends on these as well, but also on $b \in \{0,1\}$, an indicator of whether or not the business has already been started by paying the set-up cost. Thus, the state vector of individual's problem is described by a quadruple (a,z,s,b).The value of an agent facing the choice between working an entrepreneurship is then:

$$v(a,z,s,b) = \max\{v^w(a,z,s), v^e(a,z,s,b)\} \tag{1}$$

The value of a new generation facing the choice of specializing in a sector depends only

these lines, and evidence of this mechanism from the rigid disk-drive industry.

on assets:

$$v_0(a) = \max_s \{E[v(a, z, s, 0)]\} \tag{2}$$

3.3 Credit and Rental Markets

Individuals have access to competitive credit and rental markets. Financial intermediaries receive deposits, accumulate and rent capital at a rental rate R, and lend to entrepreneurs. Borrowing is between period, while capital rental is within period.

We assume that, while assets are transferred across generations, debts do not carry over to future generations.[21] Hence, the probability of death γ introduces a wedge between the deposit (r^d) and borrowing rates (r^b). Free entry and, therefore, zero profits for financial intermediaries imply:

$$\begin{aligned} \left(1+r^d\right) &= \gamma\left(1+r^b\right) \\ R &= r^d + \delta \end{aligned}$$

where δ is the depreciation rate.

Both borrowing and the rental of capital by entrepreneurs are limited due to enforcement problems. The enforcement problem is characterized by the following limited enforcement constraint:

$$u(c) + \beta\left[\gamma v(a', z, s, 1) + (1-\gamma) v_0(\max\{0, a'\})\right] \geq (1-\phi) v^e\left(a^d, z, s\right) + \phi v^{ww}(0)$$

where $a^d \equiv [k + (1-b) p_s \kappa_s]$ is the wealth that is kept by an individual if defaulting and $v^{ww}(0)$ is defined as the value function of an individual left with no assets who is excluded from becoming an entrepreneur for the rest of his life.

The left-hand side represents the value of complying with the contract, and the right-

[21] One can view this as reflecting either limited liability for firms or a prohibition on debts being transfered from parents to children, which is customary in modern societies.

hand side represents the value of reneging on rental and debt obligations. This latter value is a function of the constants ϕ, capturing the severity of the punishment associated with default as measured by the exclusion from credit and business opportunities (ϕ), and the fraction of the borrowed money that can be steel by borrowers upon defautl (ϕ).

To focus on the production role of credit markets, we abstract from borrowing by workers and require that they have a positive net-worth.

3.4 Recursive Representation of Agent's Problem

We are ready to state the Bellman equations that define the value functions of workers and entrepreneurs, $v^w(a, z, s)$ and $v^e(a, z, s, b)$.

The problem of an individual that works for a wage in the current period solves:

$$
\begin{aligned}
v^w(a, z, s) \quad &= \quad \max_{c,a' \geq 0} u(c) + \beta\gamma v(a', z, s, 0) \qquad (3) \\
& \quad\ s.t. \\
& \quad\ pc + a' \leq w + \left(1 + r^d\right) a
\end{aligned}
$$

and the value function of being an entrepreneur solves[22]

$$
\begin{aligned}
v^e(a, z, s, b) \quad &= \quad \max_{c,k,l} u(c) + \beta\gamma v(a', z, s, 1) \qquad (4) \\
& \quad\ s.t. \\
& \quad\ pc + a' \leq p_s f(e, k, l) - Rk - wl - (1 - b) p_s \kappa_s + (1 + \hat{r}) a \\
& \quad\ v^w(\phi [p_s \kappa_s (1 - b) + k], z, s) \\
& \qquad \leq u(c) + \beta [\gamma v(a', z, s, 1) + (1 - \gamma) v_0(\max\{0, a'\})] \qquad (5)
\end{aligned}
$$

where $\hat{r} = r^d (a \geq 0) + r^b (a < 0)$. Again, the tradable goods sector, which produces invest-

[22] This value function will not be well defined for certain values of the states, as the constraint set might be empty. In that case, the proper way to setup the problem would be to explicitely introduce a discrete choice. We choose the purely Bellmanized notation to better hightlight the structure of the problem.

ment goods, is the numeraire, so that $p \equiv \{p_1, 1\}$.

3.4.1 Stationary Competitive Equilibrium

A stationary competitive equilibria given by an invariant distribution of wealth, entrepreneurial ideas, sectors, and business ownership $G(a,z,s,b)$, policy functions $s(a)$, $c(a,z,s,b)$, $a'(a,z,s,b)$, $l(a,z,s,b)$, $k(a,z,s,b)$ and prices w, r^d, r^b, p such that:

1. Given w, r^d, r^b and p, $s(a)$, $c(a,z,s,b)$, $a'(a,z,s,b)$, $l(a,z,s,b)$, $k(a,z,s,b)$ solve (1), (2), , (4), and (3);

2. Financial intermediaries have zero profits

$$\left(1+r^d\right) = \gamma\left(1+r^b\right);$$

3. Credit, labor, and goods markets clear:

$$\sum_s \int aG(da,dz,s,e) = \sum_s \int k(a,z,s,e)\, G(da,dz,s,e),$$

$$\begin{aligned} &\sum_s \left[\int_{(a,z)\in\mathcal{W}(s,b)} G(da,dz,s,b)\right] \\ = &\sum_s \int l(a,z,s)\, G(da,dz,s,b), \end{aligned}$$

$$c_{NT} = \sum_b \int_{(a,z)\in\mathcal{E}(NT,b)} \left[zk(a,z,NT,b)^{\alpha}\, l(a,z,NT,b)^{\theta} - (1-b)\,\kappa_{NT}\right] G(da,dz,NT,b)$$

$$
\begin{aligned}
& c_T + \delta \sum_b \int_{(a,z)\in\mathcal{E}(T,b)} k(a,z,T,b)\, G(da,dz,T,b) \\
= & \sum_b \int_{(a,z)\in\mathcal{E}(T,b)} \left[zk(a,z,T,b)^{\alpha}\, l(a,z,T,b)^{\theta} - (1-b)\,\kappa_T \right] G(da,dz,T,b)
\end{aligned}
$$

where $\mathcal{W}(s,b) \equiv \{(a,z) : v^w(a,z,s) \geq v^e(a,z,s,0)\}$ and $\mathcal{E}(s,b) \equiv \{(a,z) : v^w(a,z,s) \geq v^e(a,z,s,0)\}$;

4. The joint distribution of wealth, entrepreneurial ideas, sectors and business ownership is a fixed point of the equilibrium mapping:

$$
\begin{aligned}
G(a,z,s,b) = & \gamma \sum_{\tilde{b}\in\{0,1\}} \int_{\tilde{a},\tilde{z}\in\mathcal{X}_1} G\left(d\tilde{a}, d\tilde{z}, s, \tilde{b}\right) \\
& + (1-b)(1-\gamma)\,\mu(z) \sum_{\tilde{s},\tilde{b}\in\{0,1\}} \int_{\tilde{a},\tilde{z}\in\mathcal{X}_2(\tilde{s})} G\left(d\tilde{a}, d\tilde{z}, \tilde{s}, \tilde{b}\right)
\end{aligned}
$$

where $\mathcal{X}_1 = \left\{\tilde{a},\tilde{z} : \tilde{z} \leq z, a'\left(\tilde{a},\tilde{z},s,\tilde{b}\right) \leq a, \left(v^e(a,z,s,0) \geq v^w(a,z,s)\right) = b\right\}$, and $\mathcal{X}_2(\tilde{s}) = \left\{\tilde{a},\tilde{z} : a'\left(\tilde{a},\tilde{z},\tilde{s},\tilde{b}\right) \leq a, s\left(a'\left(\tilde{a},\tilde{z},\tilde{s},\tilde{b}\right)\right) = s\right\}$.

3.4.2 First Best Benchmark

To clarify the basic mechanics of the model it is instructive to analyze the undistorted first best allocation. This is also the benchmark economy that we use to calibrate the technological parameters of the model, by matching key aspects of the size distribution of establishments in the US economy.

In writing this problem, we start by solving for the optimal allocation of capital and labor within sector s for a given fraction of the population specializing in the sector, n_s, a given threshold idea productivity for starting a business, $\hat{z}_s$, and a given amount of capital and labor in the sector K_s and L_s:

$$\max_{k(z),l(z)} n_s \int_{\hat{z}_s}^{\infty} zk(z)^{\alpha} l(z)^{\theta} d\mu(z)$$
$$s.t.$$
$$n_s \int_{\hat{z}_s}^{\infty} k(z)\, d\mu(z) \leq K_s$$
$$n_s \int_{\hat{z}_s}^{\infty} l(z)\, d\mu(z) \leq L_s$$

whose solution is the (gross) sectoral production function for a given distribution of firms defined by n_s and $\hat{z}_s$:

$$\tilde{Y}_s(K_s, L_s; n_s, \hat{z}_s) = \left[n_s \int_{\hat{z}_s}^{\infty} z^{\frac{1}{1-\alpha-\theta}} d\mu(z) \right]^{1-\alpha-\theta} K_s^{\alpha} L_s^{\theta}$$

Realizing that $n_{NT} = 1 - n_T$, the Bellman equation characterizing the first best allocation can be written:[23]

$$\begin{aligned} v(K) \;\; = & \max_{c,\, K',\, n,\, \hat{z}_{NT},\, \hat{z}_T} u(c) + \beta v(K') \\ & s.t. \\ & c_{NT} \leq \tilde{Y}_{NT}(K_{NT}, L_{NT}; n_{NT}, \hat{z}_{NT}) - (1-\gamma)\, \kappa_{NT} n \left(1 - \mu(\hat{z}_{NT})\right) \\ & c_T + K' \leq \tilde{Y}_T(K_T, L_T; 1 - n_{NT}, \hat{z}_T) - (1-\gamma)\, \kappa_T (1 - n_{NT}) \left(1 - \mu(\hat{z}_T)\right) \\ & K_T + K_{NT} \leq K \\ & L_T + L_{NT} \leq n_{NT} \mu(\hat{z}_{NT}) + (1 - n_{NT})\, \mu(\hat{z}_T) \end{aligned}$$

We next present two results characterizing the first best allocation for the case in which we assume ideas follow a Pareto distribution, $z \sim \eta z_m^{\eta} z^{-(\eta+1)}$. This assumption yields closed form solutions for the net sectoral production function, i.e., the output of a given sector net of the resources used to setup plants, the factor shares, and the size distribution of

[23] To simplify the exposition we abstract from the irreversibility in the sectoral choice decision, i.e., the constraint $\gamma n_1 \leq n_1' \leq \gamma n_1 + 1 - \gamma$, and do not carry the distribution of previously active entrepreneurs as a state variable. This information will only be relevant to analyze the transitional dynamics of the model.

establishments across sectors. The results also provide key insights that are used to calibrate the technological parameters of the model to match basic facts about the size distribution of establishments across sectors.

The first result shows that net output of a sector as a function of the fraction individuals specializing in a sector (n_s), the sectoral capital (K_s) and labor (L_s) inputs, is Cobb-Douglas with constant returns to scale:

Proposition 1 *Provided that ideas are distributed Pareto* $z \sim \eta z_m^\eta z^{-(\eta+1)}$, *the output of a sector net of setup costs equals:*

$$\begin{aligned} Y_s\left(K_s, L_s; n_s\right) &= \tilde{Y}\left(K_s, L_s; n_s, \hat{z}_s^*\right) - (1-\gamma)\,\kappa_s n_s\left(1-\mu\left(\hat{z}_s^*\right)\right) \\ &= A_s^* n_s^{\frac{1/\eta}{\alpha+\theta+1/\eta}} K_s^{\frac{\alpha}{\alpha+\theta+1/\eta}} L_s^{\frac{\theta}{\alpha+\theta+1/\eta}} \end{aligned}$$

where

$$A_s^* = \frac{A_s^{\frac{\eta}{1+\eta(\alpha+\theta)}}\left[\frac{(1-\alpha-\theta)}{\eta(1-\alpha-\theta)-1}\eta z_m^\eta\right]^{\frac{1}{1+\eta(\alpha+\theta)}}\left[1-\frac{(1-\gamma)\frac{p_s\kappa_s}{w}}{(1-\gamma)\frac{p_s\kappa_s}{w}+1}\left(1-\alpha-\theta-\frac{1}{\eta}\right)\right]}{\left[(1-\gamma)\frac{p_s\kappa_s}{w}+1\right]^{\frac{\eta(1-\alpha-\theta)-1}{1+\eta(\alpha+\theta)}}}$$

and

$$\hat{z}_s^* = \arg\max_{\hat{z}_s}\left\{p_s\tilde{Y}(K_s, L_s; n_s, \hat{z}_s) - \left((1-\gamma)\,p_s\kappa_s + w\right)n_s\left(1-\mu\left(\hat{z}_s\right)\right)\right\}.$$

From this result it follows that, as in the standard neoclasical sectoral growth model, the elasticities of output with respect to capital and labor are constant, $\frac{\alpha}{\alpha+\theta+1/\eta}$ and $\frac{\theta}{\alpha+\theta+1/\eta}$, respectively. Unlike in the standard model, however, the elasticities are not equal to the corresponding factor shares, since entrepreneurs earn rents. In particular, payments to capital as a share of income equals:

$$\begin{aligned} s_{K,s} &= \frac{RK_s}{Y_s(K_s, L_s; n_s)} \\ &= \frac{\alpha}{1-\frac{p_s f_s/w}{p_s f_s/w+1}\left(1-\alpha-\theta-\frac{1}{\eta}\right)}. \end{aligned}$$

Even though factor shares are not constant, for realistic parametrization of the model $1 - \alpha - \theta - \frac{1}{\eta} \approx 0$, implying that factor shares are constant for practical purposes.

We finish this section by studying the size distribution of establishments in the first best economy. In particular, we show that, within a sector, establishments are distributed Pareto with tail coefficient $\eta(1 - \alpha - \theta)$, while the size distribution over the entire economy is given by a mixture of Pareto distributions. We also show that there is a one-to-one mapping between the value of the setup cost relative to the labor cost $p_s\kappa_s/w$ and the ratio of the average employment per establishment $\bar{l}_s$ across sectors.

Proposition 2 *The distribution of employment in each sector follows a power law:*

$$\Pr\left[\tilde{l}_s > l\right] = \left(\frac{l(\hat{z}_s)}{l}\right)^{\eta(1-\alpha-\theta)}$$

where $l(\hat{z}_s)$ is the employment in the marginal establishment; while the distribution of employment in the aggregate economy is given by a mixture of Pareto distributions:

$$\Pr\left[\tilde{l} > l\right] = n_1 \left(\frac{l(\hat{z}_1)}{l}\right)^{\eta(1-\alpha-\theta)} + (1 - n_1)\left(\frac{l(\hat{z}_2)}{l}\right)^{\eta(1-\alpha-\theta)};$$

and the ratio of average employment per establishment across sectors equals:

$$\frac{\bar{l}_s}{\bar{l}_{s'}} = \frac{\frac{p_s f_s}{w} + 1}{\frac{p_{s'} f_{s'}}{w} + 1}.$$

This result suggests a simple way to calibrate the relative importance of setup cost across sectors and the parameter of the distribution of ideas by matching the ratio of average employment per establishment across sectors and the tail of the size distribution of establishments. In the next section, we use this insight to calibrate the model, and then study how credit frictions affect the relative productivity across sectors, and the size distribution of establishments.

4 Quantitative Analysis

In this section we calibrate the perfect credit benchmark to the United States economy. We then conduct experiments varying only ϕ, the parameter which captures the extent of financial frictions, to obtain variation in debt/GDP ratios that are quantitatively reasonable given the range observed in the cross-section of countries. We assess the model's predictions for TFP, prices, output and scale across sectors. Finally, we assess a testable implication of the model about variation in the relative scale of sectors vis-a-vis the data.

4.1 Calibration

We calibrate the preferences and technological parameters so that the first best economy matches standard macroeconomic aggregates and key features of the size distribution of establishments across sectors in the U.S.

We choose a degree of returns to scale to the variable factors, capital and labor, of $1 - \alpha - \theta = 0.85$, a value that falls in the range of values in the literature[24]. Given this choice, the value of α is chosen to match an aggregate share of capital of 1/3. We calibrate the setup costs, $\kappa_{NT} = 0.05$ and $\kappa_T = 6.75$, to match the average employment per establishment in the non-tradable and tradable sectors of 15 and 48, respectively. We assume that z_s is distributed Pareto, $z \sim \eta z_m^{\eta} z^{-(\eta+1)}$, and symmetrically for each sector. We normalize $z_m = \frac{\eta-1}{\eta}$, and choose the standard deviation of the distribution of entrepreneurial ideas, $\eta = 8.6667$, to match the share of employment accounted by the top 10% of establishments of 0.60.

A period in the model is set to 2 years, and we let $\gamma = 0.93$ so that the average duration of working lives is 30 years. Calibrating to the working life, which is longer than the life of the typical establishment, is conservative in the sense that entry costs will be a smaller fraction of total output. The 2-year depreciation rate is set at $\delta = 0.11$ and set $\beta = 0.9$ to match

[24] For example, this is the value used by Atkeson, Ohanian and Kahn (1996), Atkeson and Kehoe (2005), and Amaral and Quintin (2006). The set of alternative values range from 0.10 (Cagetti and De Nardi, 2006) and 0.19 (Buera and Shin, 2007).

the 2-year interest rate. We let $\sigma = 1.5$ following the standard practice. The assumption of a unitary elasticity of substitution between tradables and non-tradables is consistent with the estimate of 1.24 by Ostry and Reinhart (1991) for a group of developing countries and Mendoza's (1995) estimate of 0.74 for a group of industrialized countries.

Parameter	Value	Target
α	0.33	capital's share
θ	0.52	diminishing returns
κ_1	0.05	avg. scale in tradable sector
κ_2	6.75	avg. scale in non-tradable sector
η	9.33	top 10% employment share
z_m	0.67	normalized
γ	0.93	working life
δ	0.12	2-year depreciation
β	0.92	2-year discount rate
ε	1	trad./non-trad. elast. of subst.

Table 2: Benchmark Parameter Values

Figure 3 shows the size distribution of establishment implied by the calibrated model, and compares them with their data counterparts. The model is able to fit the tails of these distribution, the "distance" between the sectoral distributions, and the initial concavity in the aggregate distribution of establishments. The model cannot capture the initial concavity in distribution of establishment within a sector, presumably due to our abstracting from within-sector heterogeneity in the setup costs.

4.2 Numerical Examples

Table 3 gives a summary of our empirical targets in the cross-country data. Here we have divided the sample into quintiles by output per worker, and listed the statistics regarding

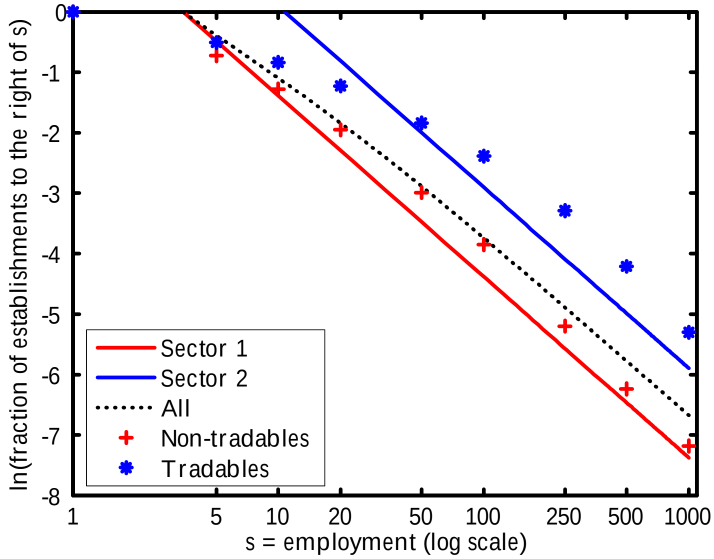

Figure 3: Size distribution of establishments across sectors, in the data (* and +) and model (solid and dash lines).

output per worker, external finance to GDP ratios and log relative price of tradables in each quintile, as well as a representative country for each quintile. One can see that both the ratio of external finance to GDP and the log relative price of tradables varies considerably within output per worker quintiles, and indeed overlap substantially across quintiles. Indeed, even the average values are non-monotonic.

We compare these empirical results to our numerical examples. We show numerical examples for two levels of financial frictions as well as the first best benchmark. The case of mild financial frictions yields an external finance/GDP ratio of 2.22, while the tighter financial frictions yields 1.30. The first corresponds well to a typical top quintile country (e.g., Belgium), while the latter is in between the first and second quintiles, roughly Spain. All of the values come directly out of the model except for output and sectoral productivity, A_s, which we calculate as typically measured in the data. Output is measured at constant ("international", i.e., first-best) prices, while sectoral TFP is calculated as $A_s = Y_s/K_s^{1/3}L_s^{2/3}$.

The results for key variables are shown in Table 4.

	Low Financial Frictions	High Financial Frictions	High-Low Percent Difference
ϕ	0.63	0.30	
External Financing/GDP	2.22	1.30	-41.5%
A_{NT}	4.1	4.0	-1.6%
A_T	3.6	3.1	-15.0%
A_T/A_{NT}	0.88	0.76	-13.6%
p_T/p_{NT}	1.10	1.22	10.5%
$z_{NT,avg}$	0.97	0.98	0.3%
$z_{T,avg}$	1.21	1.17	-3.3%
Fraction Specializing in Non-tradable Sector	0.978	0.987	0.9%
Estab. per Capita in Non-tradable Sector	0.073	0.090	22.7%
Estab. per Capita in Tradable Sector	0.008	0.003	-66.0%
$l_{NT,avg}$	6.8	5.8	-15.0%
$l_{T,avg}$	59.4	151.8	155.6%
$l_{T,avg}/l_{NT,avg}$	8.7	26.1	201.0%
w	0.34	0.29	-17.0%
r	0.10	0.07	-30.0%
K	0.87	0.66	-24.8%
Y	0.62	0.52	-16.4%

Table 3: Experimental Results

The first row shows the particular value of ϕ chosen, which is the only parameter that is varied. The second row shows the above mentioned effects on the ratio of external financing to GDP. The third and fourth rows show the effects on sectoral TFP, which, in the economy with tighter financial restrictions, is slightly lower (1.5 percent) in the non-tradable sector, but substantially (15.0 percent) lower . Consequently, the relative TFP of the tradable sector in row 5 is about 14 percent lower in the economy with stronger financial frictions. Likewise, the relative price of the tradable sector increases about 10 percent as well. This is substantial. Using these two values for relative prices and external financing to GDP would yield an elasticity of (10.5/41.5=) 0.25 or roughly three-fourths of empirical estimate of 0.32. (Clearly, further examples that span the range of financial development are necessary.)

The rows that follow show the source of this change in relative TFP. First, the average quality of entrepreneur ($z_{T,avg}$) falls in the tradable sector because there are profits to be made, even for low-skill entrepreneurs, provided one can has enough means to start and run the large-scale, tradable project. The number of people specializing in the tradable sector falls, as low wealth individuals select into the small-scale sector. This selection is substantial leading to fewer establishments in the large-scale tradable sector, even given the lower threshold for productivity, and more establishments in the small-scale sector.

This highlights the second force affecting TFP: fewer firms are started in the tradable sector because of reduced credit. Given the higher prices, there are profits to be had for those with means. This leads to larger establishments, which are less productive. The average number of workers per establishment in the large-scale sector rises from 59.4 to 151.8, while the size of nontradables falls from 6.8 to 5.8. The relative scale of tradables is therefore larger in the economy with higher financial frictions, 26.1 vs. 8.7.

Finally, we note the effect on wages, capital and output. Wages fall by 17 percent, or somewhat more than sectoral TFPs. The lower wages are an additional force leading to more firms in the low-scale, non-tradable sector. The drop in output is similarly 16 percent. About half of this decline is driven by the fall in TFP, while the remaining half is driven by a decline in capital. Capital falls by 25 percent, and since its share is 1/3, it contributes about 8 percent to the output decline.

4.3 A Testable Implication

The simulations confirm the intuition that financial frictions are relatively more harmful to TFP in the high entry cost, large-scale sectors. A surprising result, however, is the effect of financial frictions on average scale in equilibrium; tighter financial frictions lead to greater disparity in scale in between the high- and low-entry cost sectors. This is the result of the lower average wages. Given low wages, (very) small-scale entrepreneurship is more desirable because the opportunity costs (i.e., the income from being a worker) is lower. Conversely, those who have the means to finance the large scale entry cost face high output prices and lower labor costs that lead to larger scale establishments.

While absolute scales of sectors are governed by absolute productivity levels, which presumably vary across countries, the prediction that the relative average scale of the tradable sector is decreasing with income (or financial frictions) is a testable implication.

Evaluating this requires data sources for scale that are comparable across countries. We have two sources. First, the Economic Censuses in the U.S. and Mexico are both based on the NAICS 2002, an establishment level classification, very well documented, and broadly comparable. We drop those industries that are not collected on a comparable basis.[25] Second, the OECD SSIS data is less well-documented but is designed for comparability. It contains data on workers, establishments, and enterprises according to the common ISIC3.2 classification. Unfortunately, not all countries have complete coverage of industries, and only the U.S. provides both establishment and enterprise data. For comparison, we chose two groups of countries: the three large advanced economies (Britain, France and Germany) and the eight poorest countries available (Czech Republic, Hungary, Poland, Portugal, Slovak Republic, South Korea, and Turkey).[26] Korea and Turkey provide establishment data, while the others provide enterprise data. Given our focus on financing, we drop government

[25] Construction, mining, transportation, FIRE, telephone, postal service, electricity and water are all collected at the firm level in Mexico.

[26] The data is for 2002. When not available we use 2001 or 2003. Data on three advanced economies (Australia, Canada, Japan) and one poorer country (Mexico) lacked coverage of broad sectors of the economy.

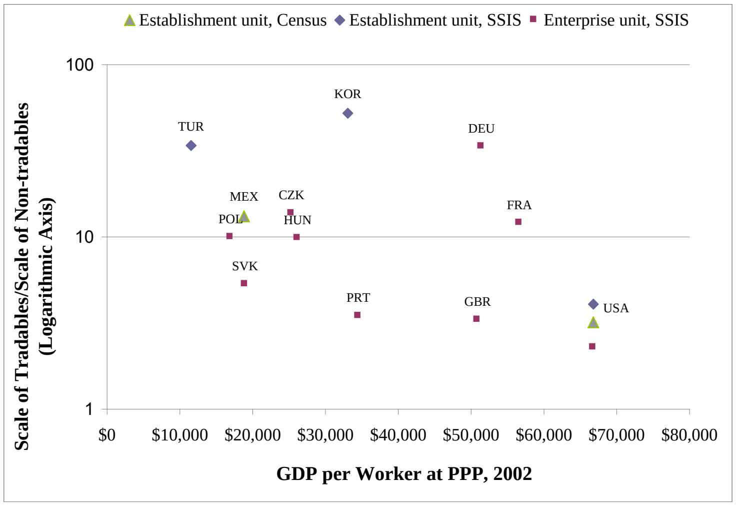

Figure 4: Relative Scale vs. Output per Worker, 12 Countries

as well as industries that are extreme outliers and are substantially government financed: air transportation, central banking, postal service, and rail transportation. For all measures we calculate the unweighted average scale for the tradable and non-tradable sector, and take the ratio of the two.

The results for these three comparisons are shown in Figure 3, which plots the scale of tradables relative to non-tradables on the logarithmic vertical axis and output per worker on the horizontal axis.[27] The U.S. is in the lower right-hand corner, and has fairly similar values for all three measures of scale. Focusing on the triangles, we see that in Mexico the relative scale of tradables establishments is larger in Mexico than in the U.S. This is also true of establishments in Korea and Turkey vs. the U.S., which are plotted using the diamonds. The slope between relative scale and external finance in these data are comparable to that calculated in the numerical examples (roughly -18), but the slope for Mexico is much flatter than in the numerical examples.

The squares shows that in the poorer countries also have the relative scale of tradables

[27] GDP per worker taken from PWT 6.2 . SSIS is the OECD Structural Statistics for Industry and Services using ISIC 3-digit classification. The Census data is from U.S. and Mexican Economic Censuses using the NAICS classification. Excludes government run industries such as air and rail transportation, central banking, and public utilities.

enterprises is larger than in the U.S. that are more in line with the numerical examples, but the relationship is not as strong or systematic. In particular, relative scale is smaller in France and especially Britain, although their ratios of external finance to GDP are lower than in the United States. In contrast, relative scale of tradables is larger in Germany, driven by automobile manufacturing enterprises, which are substantially larger in Germany (2803) than in the U.S. (162) and other countries.

5 Conclusions

The paper has developed an explicit theory linking countries levels of financial development to their relative productivity in the tradable sector, and the equilibrium relative price of tradables. Tradable productivity is more sensitive to financial frictions because tradables require entail large set-up costs that often require external financing. Moreover, we have shown that this mechanism is quantitatively important, potentially explaining three-quarters of the observed relationship between financial development and relative prices in the cross-country data. Through this channel, both productivity and capital accumulation are lowered by financial frictions, thus financial development becomes quantitatively important for income per capita. Finally, we have shown that the implied mechanism is consistent with the large differences in average scale across sectors observed in poor countries. Thus, the analysis shows how emphasis on the size distribution of microtechnologies (firms or establishments) is informative about macroissues such as productivity, relative prices and capital accumulation.

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