

Finance and Development: A Tale of Two Sectors*

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September 23, 2008

Abstract

Explaining levels of economic development hinges on explaining TFP differences across countries. In poor countries, total factor productivity (TFP) is particularly low in sectors producing tradable goods. 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 aggregate TFP, sectoral TFPs, and scales across industrial sectors. In our model, financial frictions disproportionately affect TFP in tradable sectors where production requires larger fixed costs. Our quantitative exercises show that financial frictions explain a substantial share of the observed cross-country relationship between aggregate TFP, sectoral TFP, and output per worker.

*We have benefited from comments received at 2007 SED Meeting, Arizona State University, FRB Minneapolis, and the University of Chicago.

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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 equipment and goods that can be traded for equipment.¹ Besides directly explaining the level of per-capita output, sectoral productivity levels are also central in explaining cross-country variation in capital accumulation because differential productivities affect the relative price of equipment.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 aggregate and sectoral-level TFP based on cross-country differences in financial development and cross-sector differences in the optimal scale of establishments. Both of these underlying premises have strong empirical support.

The first premise, cross-country differences in financial development and their underdevelopment in poor countries in particular, has been well-established in the literature. King and Levine (1993) and Beck et al (2000) show that aggregate measures of credit and financial development are strongly related to output per capita, while La Porta et al (1998) document that these macroindicators are

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

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

strongly related to underlying institutional differences like the enforcement of contracts, creditor protection, etc. Banerjee and Duflo (2005) review the micro-evidence for credit constraints in poor countries and their important role in the misallocation of capital. Hsieh and Klenow (2007b) show that, when producers have heterogeneous productivity, misallocations can have a large effect on aggregate productivity in China and India. Townsend (forthcoming)'s study of Thailand is more explicit in linking observed misallocations to micro-level credit constraints and showing how their relaxation through financial development leads to rapid growth.

The first contribution of this paper is to establish the second premise: cross-sectoral differences in establishment size, measured as workers per establishment. Using detailed sectoral data, we document that the average establishment in the tradable sector is three times as large as that in the non-tradable sector in the U.S.³, and large sectoral differences in establishment size are robustly observed in a wide range of countries. 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. Hence, establishment size appears to be a deep and important technological distinction.

These observations lead us to study a model with sectoral scale differences and to quantify how financial frictions distort scales of operation in the different sectors.

We model production in which heterogeneous entrepreneurs face fixed costs of operating an establishment. Entrepreneurs face limited span of control, however, so that average cost curves are U-shaped. Sectors differ in their fixed costs, and hence their profit-maximizing scale. Tradable sector establishments face a large fixed cost, and hence operate at a large average scale. Heterogeneous agents choose sectors and occupations. Individuals differ in their sector-specific entrepreneurial productivities and in their wealth, with the latter being endogenously determined by the interaction of forward-looking saving decisions and the process for productivity. The heterogeneity in the productivity of entrepreneurs leads to within-sector variation in the size of establishments.

In a frictionless economy, sectoral and occupational choices are based on comparative advantage; the most able individuals become entrepreneurs and the distribution of capital equalizes marginal products of capital across sectors and establishments. With financial frictions – which we model with endogenous enforcement constraints – entrepreneurs' investment decisions are constrained by

³Buera and Kaboski (2008) document related differences in establishment size between manufacturing and services.

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. Financial frictions distort these decisions, leading to suboptimal entry of entrepreneurs, lower average productivity, and suboptimal investment and scale. These effects of financial frictions are disproportionately manifest in the large-scale tradable sector.

We provide a quantitative analysis of our theory of TFP across countries and across sectors. We discipline the analysis by requiring that a benchmark model with well-functioning credit markets matches a rich set of moments on sector-specific size distributions of establishments across sectors and within sectors, e.g., average differences in size across sectors, thick right-tails within broadly defined sectors, the dynamics of establishments, and income concentration by entrepreneurs. We then employ data on the use of external financing to calibrate the variation in financial development across countries and quantify its effect on TFP. Finally, we leave cross-country data on the size distribution to be used as overidentifying restrictions to test additional implications of the theory.

We find financial frictions to be quantitatively important in explaining the implied patterns in relative TFP between tradables (large-scale) vs. non-tradable (small-scale) output. In our baseline calibration, these frictions can produce incomes as low as half of the output per worker in the United States. Although not yielding the full variation in output per worker or relative TFP observed in the data, the model nonetheless roughly reproduces the implied cross-country elasticity between the two. Most of the variation in relative TFP is due to the differential effect on the average ability of entrepreneurs in a sector, while the balance comes from differential levels of misallocation of capital and labor among entrepreneurs.

The patterns of relative TFP are directly linked to patterns in relative prices, hence we equivalently explain nearly all of the cross-country elasticity of the relative price of tradables with respect to output per worker. The higher relative price of the tradable investment goods in the model leads to lower rates of capital accumulation in poor countries. The baseline model explains XX of the variation in steady state capital/output ratios, which in turn explains about XX percent of the variation in observed output per worker across countries. The misallocations caused by financial frictions also lower aggregate TFP, however, and these account for XX of the observed variation in aggregate TFP, and in turn forty percent of the variation of output. Again, together these two effects can produce output per worker as low as $\frac{1}{4}$ half of that in the United States.

Our mechanism for differential impact of financial frictions across sectors yields a novel and important testable implication on the relative size of tradable vs. non-tradable establishments in an economy with strong financial frictions. Namely, the frictions, together with the higher relative price of tradables and lower wages that result from them, lead to too many entrepreneurs with too small of establishments in the non-tradable sector, and too few entrepreneurs with too large of establishments in the large-scale sector.⁴ We evaluate this implication empirically with detailed data designed for cross-country comparability. Using OECD data for a broad set of eleven countries whose levels of development vary, we show that the relative scale of tradable establishments is substantially larger in poorer countries. We supplement this evidence with a detailed case study of the U.S. and Mexico, which integrates Economic Census data (based on the common North American Industrial Classification System) with a Mexican survey of small businesses (which provides data on small-scale, mobile, informal entrepreneurs). Average scale in Mexico is substantially lower overall, but within the tradable sector, industries with large-establishments in the U.S. tend to have even larger establishments in Mexico. These also tend to be industries associated with a high degree of dependence on external finance.

Related Literature This paper is most closely related and complementary to two others in the literature that emphasize the differential effects of financial frictions on manufacturing industries.⁵ 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. We reconstruct their measure of industry-specific financial dependence for our analysis of Mexico and the U.S. mentioned above and show that differences in scale between the U.S. and Mexico are significantly related to the industry’s index of financial dependence. That is, Mexico has larger establishments (relative to the U.S.) in financially dependent industries. Erosa and Hidalgo (forthcoming) is a theoretical

⁴We focus less on the implications for absolute establishment sizes, since we view financial frictions as one of many potential factors distorting the average scale of establishments in developing countries. Technological differences is one obvious difference. Hsieh and Klenow (2007b) highlight the importance of idiosyncratic firm-level distortions, while Guner, Ventura, and Yi (2007) document specific and direct policy distortions including differential taxation and hard restrictions on scale, and find them to have quantitative importance.

⁵This paper also contributes to a vast literature relating financial frictions and entrepreneurship to development, including theoretical contributions by: Aghion and Bolton (1997), Banerjee and Newman (1991), Castro, Clemente and McDonald (2007), Lloyd-Ellis and Burnhardt (2001), Piketty (1997); and relatively fewer macro-quantitative studies by: Amaral and Quentin (2006), Buera and Shin (2007), Gine and Townsend (2004), Jeong and Townsend (2006).

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 evaluates the size distribution implication of the theory using detailed sectoral data from the U.S., Mexico and the SSIS panel. Section 5 concludes.

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 6.2.⁶ Here the relative price is produced by creating Geary-Khamis aggregated prices for tradables and nontradables sectors using 27 disaggregated product categories.⁷ The relative price of tradables

⁶There 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.

⁷The 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”.

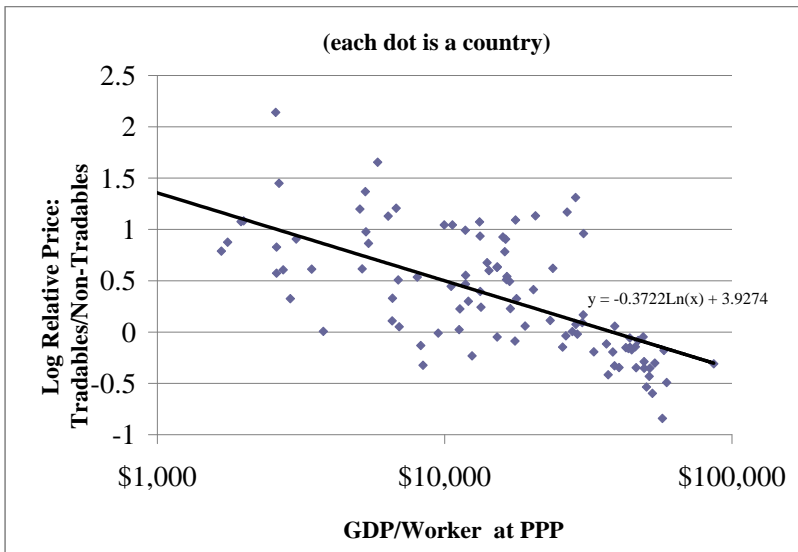


Figure 1: GDP/Worker

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.⁸ Differences in factor shares and the relative supply 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.⁹ 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

⁸See, for example, Hsieh and Klenow (2007) who use this relationship to identify aggregate distortions between capital and labor and sectoral TFP differences.

⁹See Herrendorf and Valentinyi (2007b) for physical capital and Buera and Kaboski (2007a) for human capital.

(LaPorta et al, 1998, Rajan and Zingales, 1998). The relationship between relative prices and external financing to GDP ratios (taken from Beck et al, 2000) is quite similar to the Figure 1 relationship between relative prices and GDP. The estimated elasticity of 0.32 is slightly lower, but the R^2 of 0.50 is slightly higher.

A priori, the strength of the relationship points to financial development as potentially strongly related to the Balassa-Samuelson fact. In the model we develop, it is financial development rather than output per worker that is the causal force behind both relative prices and output differences. A simple joint regression of log relative prices on both log GDP/worker and log external financing/GDP gives suggestive evidence toward this interpretation. 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.¹⁰

2.3 Scale Differences Across Sectors

The second key fact that motivates our study is the large difference between tradables and non-tradables in the average scale of productive units. These sectoral scale differences are suggestive of technological differences. We will argue that these technological differences interact with financial development, so that financial development affects large- and small-scale sectors differentially. 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.¹¹

Table 1 presents measures of average scale across broad final goods sectors of the U.S. economy.¹² 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 be used for comparison

¹⁰Measurement 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.

¹¹The 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 include some types of temporary or contract workers. For some countries, we have both measures, and the two mirror each other well.

¹²These 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 accommodation/food services, arts/entertainment, communication, education, FIRE, health, retail, sewage, transportation, and wholesale.

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.¹³ We present simple averages, a measure of interest to our model and calibration.

	OECD SSIS Data		U.S. Census Data
	Workers	Workers	Workers
	per Estab.	per Enterp.	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.¹⁴

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.¹⁵ 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).¹⁶

¹³There are also subtle differences in definitions of workers across the two samples. In particular, the SSIS data measures “number of persons engaged”, which includes proprietors. The census data is “number of employees” and excludes proprietors.

¹⁴The data are simple averages across establishments, calculated by weighting 4-digit industries (OECD SSIS data) and 8-digit industries in the U.S. census data by the number of establishments in a industry. 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.

¹⁵We 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.

¹⁶Buera 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 fixed costs across sectors. 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, and data availability also dictates which measure we use in some cases.

2.4 Relative Prices and Scale

We have seen that the relative price of tradables is high in poor countries and that tradables are also large scale. A natural question to ask is whether relative prices and scale are related at a finer level. We examine this using disaggregated ICP price data from the 1996 benchmark. We map these disaggregated ICP categories into measures of scale using the U.S. Economic Census data. We proxy a ranking of the optimal scales of technology by taking average scale across an available set of eight countries with comparable data.¹⁷ We then map ICP categories into closely matched groups of industries and calculate average scale for these industry groups.¹⁸ Finally, we ran cross-country regressions of 2794 disaggregated ICP price data from 112 countries log output per worker, log industry scale, and the interaction of log income and log scale. The resulting regression equation is (with t-stats in parentheses):

$$\log p_{i,s} = -7.25 + 0.71 \log(y_i) + 0.97 \log(\bar{l}_s) - 0.10 \log(y_i) \log(\bar{l}_s), \quad R^2 = 0.21$$

(-13.0)
(12.2)
(6.5)
(-6.2)

where $p_{i,s}$ is the 1996 price of sector s in country i , y_i is the output per worker in 1996 international prices, \bar{l}_s is the average number of workers engaged per enterprise. The coefficient of -0.10 on the interaction term indicates that prices of the output of industries with large optimal scale are relatively high in low income countries. Given the log difference between tradables and non-tradables above, i.e., $\log(48/15)=1.2$, The coefficient of -0.10, implies a relative price elasticity with respect to output per worker of 12 percent, about one-third of the full relationship in Figure

¹⁷OECD SSIS data – which covers all industries, not just manufacturing – is available for eight countries (Britain, Czech Republic, France, Germany, Hungary, Poland, Portugal, Slovak Republic), but only at the enterprise level. We therefore use number of persons engaged per enterprise as our measure of scale. At a disaggregated level, there is a high correlation among scale in different countries. However, we average across many countries to smooth out idiosyncratic variation that comes from variation in local market structure, government regulations, etc.

¹⁸A reliable mapping could not be done for four of the 29 ICP categories: “other household goods”, “operation of transportation equipment”, “other goods and services”, and “collective consumption by the government”. Also, due to a lack of data on agriculture, only the scale of food *manufacturing* establishments could be used. It is at least comforting that none of the food categories appeared to be outliers.

1 above. Still, mismeasurement in scale at a disaggregate level would make our estimate of -0.10 a lower bound.

The general magnitude and significance of this result at a 5 percent level is remarkably robust. Alternative specifications used country-specific fixed effects in place of controlling for $\log(y_i)$, category-specific fixed effects in place of controlling for $\log(\text{scale}_s)$, and $\log(\text{external finance}/\text{GDP}_i)$ in place of $\log(y_i)$ in both the level and interaction terms. The significance of the result at the 5% level was also robust to clustering standard errors by country or ICP category.

Why might poor countries, with underdeveloped credit markets, be particularly unproductive in operating technologies with large optimal scales? In sectors where the optimal scale is larger, entrepreneurs who cannot borrow due to credit constraints take longer to self-finance their capital. Moreover, to the extent that scale reflects large set-up costs, we view scale as being directly related to financial dependence.¹⁹ The fact that poor countries tend to have lower levels of financial intermediation and lower levels of investor protection has been well-documented in other existing papers (see King and Levine, 1993, and LaPorta et al,1998). The rest of the paper develops a quantitative model to 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 consumption sector), T (large-scale, investment goods/tradable consumption 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, with only one tradable good, openness will simply set the price of the tradable output.

There is a measure N of infinitely lived individuals. Individuals are heterogeneous in their initial wealth (a) and the quality of their entrepreneurial ideas, $z = (z_{NT}, z_T)$. The vector of entrepreneurial ideas is drawn from the distribution $\mu(z)$. Entrepreneurial ideas “die” with a constant hazard rate of $1 - \gamma$, and a new vector of ideas is drawn from the distribution $\mu(z)$. The parameter γ therefore controls the persistence of the process of entrepreneurial ideas.²⁰

¹⁹Indeed, 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.

²⁰In a life-cycle interpretation of the model this can be due to the fact that the current generation dies and is

In each period, agents choose their consumption, savings and occupation, i.e., whether to work for a wage or operate a business in sector NT or T . Agents' occupational choices are based on their comparative advantage z and their access to capital. Access to capital is limited by agents' wealth a because individuals cannot commit to repay their debts and rental contracts.

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

$$U(c) = E \left[\sum_{t=0}^{\infty} \beta^t u(c_t) \right] \quad (1)$$

where $u(c_t) = \left(c_{NT}^{1-1/\varepsilon} + c_T^{1-1/\varepsilon} \right)^{\frac{1-\sigma}{1-1/\varepsilon}} / 1 - \sigma$, β is the discount factor, σ the coefficient of risk-aversion (and the reciprocal of the intertemporal elasticity of substitution), and ε is the intratemporal elasticity of substitution between non-tradables and tradables. The expectation is over the realizations of the sequence of entrepreneurial ideas (z), which depend on the stochastic draws from $\mu(z)$ and stochastic death of ideas (γ).

Technology At the beginning of a period, an individual with vector of entrepreneurial ideas z and wealth a choose whether to work for a wage w or operate a business in any sector $s = NT, T$. To operate a business, individuals must pay a sector-specific fixed cost of κ_s units of the sector's output to run an establishment.²¹ The crucial assumption is that the fixed cost to run a establishment in the tradable sector is larger than that of the non-tradable sector, $\kappa_T > \kappa_{NT}$.

After paying the fixed cost, an entrepreneur with talent z_s produces using capital (k) and labor (l) according to the following function:

$$z_s f(k, l) = z_s k^\alpha l^\theta$$

where α and θ gives the elasticity of output with respect to capital and labor, and $\alpha + \theta < 1$

replaced by someone that does not share the same talent. Alternatively, this shock can be interpreted as changes in the "market conditions" that changes the profitability of individual skills.

²¹We also consider an extension where the sectoral scale differences are driven by one-time setup costs. In this extension, we need to carry an additional state variable $b = 0, NT, T$, telling us whether in the previous period an individual was a worker, an entrepreneur in the NT sector, or an entrepreneur in the T sector. Obviously, credit frictions will have larger impacts when financing needs are frontloaded as is the case with set-up costs

implying that there are diminishing returns to scale to variable factors at the plant level.

Given factor prices R and w , the profit of an entrepreneur equals

$$\pi_s(k, l; R, w, p) = p_s z_s k^\alpha l^\theta - Rk - wl - p_s \kappa_s$$

For later reference, it is convenient to define the (unconstrained) optimal level of capital and labor inputs in the case that production is not subject to financial constraints

$$(k_s^u, l_s^u) = \arg \max_{k, l} \left\{ p_s z_s k^\alpha l^\theta - Rk - wl \right\}.$$

Credit and Rental Markets Individuals have access to competitive financial intermediaries, who: 1) receive deposits, 2) accumulate and rent capital k at a price R , and 3) lend to entrepreneurs to finance their fixed cost $p_s \kappa_s$. In the benchmark model we restrict the analysis to the case where both borrowing and capital rental are within a period, i.e., $a \geq 0$.²² The zero profit condition implies the rental rate of capital, $R = r + \delta$, where r is the deposit and lending rate and δ is the depreciation rate.

Both borrowing and the rental of capital by entrepreneurs are limited due to enforcement problems. In particular, we assume that after production have taken place individual have the option to default carrying a fraction $(1 - \phi)$ of the revenue net of labor payments and the undepreciated capital, $(1 - \phi) [p_s z_s f(\tilde{k}, l) - wl + (1 - \delta)k]$. The only punishment associated with default is the garnishment of an amount $\phi(k + p_s \kappa_s)$ of assets and the exclusion from rental and credit markets in the current periods. In the following periods agents regain access to financial markets.

We consider equilibrium where the rental of capital is guaranteed to be honored (enforceable). In particular, we study equilibrium where the rental of capital is restricted to be lower than a rental limit $\bar{k}^s(a, z; \phi)$, a sector specific function of the individual state (a, z) . We choose the rental limits $\bar{k}^s(a, z; \phi)$ to be the largest limits that are consistent with entrepreneurs repaying their rental and borrowing contracts. Without loss of generality, we restrict rental limits to $\bar{k}^s(a, z; \phi) \leq k_s^u(z)$.

The following proposition provides a simple characterization of the set of enforceable contracts and the rental limits $\bar{k}^s(a, z; \phi)$.

²²When considering the case κ_s is a one-period setup cost (see footnote 21), we allow for between periods borrowing, i.e., $-\underline{a} \leq a' < 0$. The lower bound \underline{a} is defined to be the most generous debt limit that is enforceable conditional on borrowers not being hit by an ability shock, i.e., $z' = z$.

Proposition 1 *i) Capital rental k in sector s by an entrepreneur with wealth a and talent z is enforceable iff*

$$\begin{aligned} & p_s z_s f(k, l) - wl - Rk - (1+r)p_s \kappa_s + (1+r)a \\ & \geq (1-\phi) [p_s z_s f(k, l) - wl + (1-\delta)k]. \end{aligned} \tag{2}$$

ii) The largest limits that are consistent with entrepreneurs repaying their rental and borrowing contracts and $\bar{k}^s \leq k_s^u(z)$ are given by a function $\bar{k}^s(a, z_s; \phi)$ that is increasing in a , z_s and ϕ .

Proof. See Appendix. ■

Condition (2) simple states that the income of an entrepreneur repaying hers rental and credit obligations (left-hand side) has to be at least as large as the income of a defaulting entrepreneur (right-hand side). That this condition is sufficient to characterize enforceable allocations follows from the assumption that defaulting entrepreneurs regain access to financial markets in a period.

This proposition also provides a convenient way to operationalize the enforceability constraint using simple rental limits $\bar{k}^s(a, z; \phi)$.²³ As long as the unconstrained level of investment is not enforceable, the rental limit $\bar{k}^s(a, z; \phi)$ is implicitly defined as the larger root of the equation given by the equality in condition (2). Rental limits increase with the initial wealth of entrepreneurs as the amount that needs to be externally financed decreases and so does the temptation to default. Similarly, rental limits increase with the talent of an entrepreneur due to the fact that talents and capital input are complementary, and that defaulting entrepreneurs are relatively less capitalized.

In the rest of the paper, we restrict individual's capital inputs to be not greater than the rental limits $\bar{k}^s(a, z; \phi)$. The rental limits are parametrized by the scalar ϕ . This one-dimensional parameter captures the extent of frictions in the financial market due to imperfect enforcement of credit and rental contracts. While the enforceability of contracts as measured by ϕ does not vary across sectors, due to technological differences across sectors the extend of equilibrium enforceable rental contracts as captures by the rental limits $\bar{k}^s(a, z; \phi)$ does varies across sectors. This specification allows for a flexible model of limited commitment that spans economies with no credit $\phi = 0$ and

²³In general, the set of enforceable capital rentals does not correspond to $k \leq \bar{k}^s(a, z; \phi)$. For example, an entrepreneur that is only offered the rental of a very low (and unproductive) level of capital will default provided $p_s \kappa_s$ is large enough. Notwithstanding this, the solution to the individual's problem subject to the rental limits coincide with the solution of the individual's problem subject to the choice of enforceable capital rental contracts.

and perfect credit markets $\phi = 1$.

Recursive Representation of Agent's Problem In this section, we discuss the problem solve by individuals. In particular, we present the Bellman equations that define the value of an individual's problem before the occupational choice $v(a, z)$, and the value of workers and entrepreneurs in sector s , $v^w(a, z)$ and $v^s(a, z)$.

Individuals maximize (1) by choosing sequences of consumption, wealth, occupations, the sector where to start a business if they choose to be entrepreneurs, capital and labor inputs, subject to a sequence of period budget constraints and rental limits. In what follows, we discuss in more detail the individual's problem recursively.

At the beginning of a period, the individual's state is given by her wealth a and vector of abilities z . The individual then get to choose between being a worker or become an entrepreneur in sector NT or T . The value of an individual at this stage $v(a, z)$ equals the maximum over the value of being a worker $v^w(a, z)$ and the value of being an entrepreneur in sector s $v^s(a, z)$, $s = NT, T$,

$$v(a, z) = \max \{v^w(a, z), v^{NT}(a, z), v^T(a, z)\} \quad (3)$$

Here, the value of being a worker $v^w(a, z)$ depends on an agent's assets a , but also the productivity z of an agent's ideas which may be implemented at a later date. Similarly, the value of being an entrepreneur in sector s , $v^s(a, z)$, depends on the entire vector of entrepreneurial ideas, as they may switch sectors at a latter stage. We discuss the Bellman equations defining these value functions next.

Conditional on choosing to be a worker, an individual choose consumption c and tomorrow's assets a' to maximize the continuation value of the problem subject to a standard period budget constraint. Using , the problem of an individual that works for a wage in the current period solves:

$$\begin{aligned} v^w(a, z) &= \max_{c, a' \geq 0} u(c) + \beta [\gamma v(a', z) + (1 - \gamma) E_{z'} [v(a', z')]] \\ & \quad s.t. \\ & \quad pc + a' \leq w + (1 + r)a \end{aligned} \quad (4)$$

where p to denote the vector of sector-specific prices and the current income is given by the wage w and the asset income $(1+r)a$. The continuation value is a function of the end of period state (a', z') , with $z' = z$ with probability γ and $z' \sim \mu(z')$ with probability $1 - \gamma$. In the subsequent period, individuals again get to choose occupation and the continuation value is given by the function $v(a, z)$.

Alternatively, agents can choose to become entrepreneurs in sector s , $s = NT, T$. The value function of being an entrepreneur in sector s solves the following Bellman equation:

$$\begin{aligned}
v^s(a, z) &= \max_{c, a', k, l \geq 0} u(c) + \beta [\gamma v(a', z) + (1 - \gamma) E_{z'} [v(a', z')]] & (5) \\
& \text{s.t.} \\
pc + a' &\leq p_s f(z_s, k, l) - Rk - wl - p_s \kappa_s + (1 + r)a \\
k &\leq \bar{k}^s(a, z; \phi) & (6)
\end{aligned}$$

where entrepreneur's income is given by period profits $p_s f(z_s, k, l) - Rk - wl$ net of fixed costs $p_s \kappa_s$ plus the return to their initial wealth, and their choices of capita input are constrained by the rental limits $\bar{k}^s(a, z; \phi)$.

Stationary Competitive Equilibrium A stationary competitive equilibria is given by: an invariant distribution of wealth and entrepreneurial ideas $G(a, z)$; policy functions $o(a, z)$, $c(a, z)$, $a'(a, z)$, $l(a, z)$, and $k(a, z)$; rental limits $\bar{k}^s(a, z; \phi)$, $s = NT, T$; and prices w , R , r , and p such that:

1. Given $\bar{k}^s(a, z; \phi)$, w , R , r and p , $o(a, z)$, $c(a, z)$, $a'(a, z)$, $l(a, z)$, $k(a, z)$ solve (3), (4), and (5);
2. Financial intermediaries have zero profits, $R = r + \delta$;
3. Rental limits $\bar{k}^s(a, z; \phi)$ are the most generous limits satisfying conditions (2) and $\bar{k}^s(a, z; \phi) \leq k_s^u(z)$;
4. Credit, labor, non-tradable consumption, and tradable consumption and investment goods markets clear;

5. The joint distribution of wealth and entrepreneurial ideas is a fixed point of the equilibrium mapping:

$$G(a, z) = \gamma \int_{\tilde{a}, \tilde{z}: \tilde{z} \leq z, a'(\tilde{a}, \tilde{z}) \leq a} G(d\tilde{a}, d\tilde{z}) + (1 - \gamma) \mu(z) \int_{\tilde{a}, \tilde{z}: a'(\tilde{a}, \tilde{z}) \leq a} G(d\tilde{a}, d\tilde{z})$$

3.1 Perfect Credit Benchmark

To clarify the basic mechanics of the model, it is instructive to analyze the perfect credit benchmark, $\phi = 0$. This is an economy with perfect borrowing and lending but with no insurance. We will later use this benchmark economy to calibrate the technological parameters of the model, by matching key aspects of the size distribution and dynamics of establishments, and the concentration of income in the U.S. economy.

We present two results characterizing the production side of the perfect credit economy for the case in which entrepreneurs are a small fraction of the population and ideas follow independent Pareto distributions, $(z_T, z_{NT}) \sim \eta (z_T z_{NT})^{-(\eta+1)}$. These assumptions yield closed form solutions for the net sectoral production functions (i.e., sectoral output net of output used for fixed costs), the factor shares, and the size distribution of establishments across sectors. The assumptions also imply that the size distribution of establishments within each sector exhibits a thick tail, a key feature of the data.²⁴ These results 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 and the concentration of income.²⁵

The first result is that net output of a sector is a Cobb-Douglas, constant-returns-to-scale function of the size of the population (N), the sectoral capital (K_s) and labor (L_s) inputs.

Proposition 2 *Provided that ideas are independently distributed Pareto $(z_{NT}, z_T) \sim \eta^2 (z_{NT} z_T)^{-(\eta+1)}$, and entrepreneurs are a small fraction of the population, the output of a sector net of fixed costs*

²⁴If instead entrepreneurial ideas were to be correlated across sectors, the model would deliver a (counterfactual) thin tail for the distribution of establishments in the sector with low fixed costs.

²⁵We solve the perfect credit benchmark in two steps. First, given an aggregate supply of capital and the intratemporal (homothetic) consumption decision, we solve for optimal production decisions, occupation choices, and prices. We then use the wage and entrepreneurial profits coming from the production side of the economy to solve for the aggregate savings of individuals facing idiosyncratic shocks to their entrepreneurial ideas. A stationary equilibrium is a fixed point of these two problems.

equals:

$$Y_s(K_s, L_s; N) = A_s N^{\frac{1/\eta}{\alpha+\theta+1/\eta}} K_s^{\frac{\alpha}{\alpha+\theta+1/\eta}} L_s^{\frac{\theta}{\alpha+\theta+1/\eta}}$$

where

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

Proof. See Appendix. ■

From this result it follows that, as in the standard neoclassical 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:

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

Even though factor shares are not precisely constant, for realistic parametrizations of the model, $1 - \alpha - \theta - \frac{1}{\eta} \approx 0$, and factor shares are approximately constant.

Our second result addresses the size distribution of establishments in the benchmark economy. In particular, we show that establishments in either sector are distributed Pareto with tail coefficient $\eta(1 - \alpha - \theta)$, and the overall establishment size distribution is a mixture of Pareto distributions. We also show that there is a one-to-one mapping between the value of the fixed 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 3 *Provided that ideas are independently distributed Pareto $(z_{NT}, z_T) \sim \eta^2 (z_{NT} z_T)^{-(\eta+1)}$, and entrepreneurs are a small fraction of the population, 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:

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

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

$$\bar{l}_s / \bar{l}_{s'} = (p_s \kappa_s / w + 1) / (p_{s'} \kappa_{s'} / w + 1).$$

Proof. See Appendix. ■

This last result suggests a simple way of identifying (i) the relative importance of fixed cost across sectors and (ii) the parameter of the distribution of ideas by matching (a) the ratio of average employment per establishment across sectors and (b) the tail of the size distribution of establishments, respectively. 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 external finance/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 the model's implications for variation in the relative scale of sectors vis-a-vis the data from developing and developed countries.

4.1 Calibration

We calibrate preferences and technological parameters so that the perfect credit economy matches aspects of the U.S. (a relatively undistorted economy): standard macroeconomic aggregates, key features of the size distribution and dynamics of establishments across sectors, and the concentration of entrepreneurial income.

We need to specify values for eight parameters: four technological parameters, α , ν , κ_{NT} and

κ_T ; the depreciation rate, δ ; two parameters describing the common process for ability, γ and η ; the subjective discount factor, β , the reciprocal of the intertemporal elasticity of substitution, σ , and the intratemporal elasticity of substitution, ε .

Two preference parameters, σ and ε , and two technological parameters, $\frac{\alpha}{\alpha+\theta}$ and δ , can be chosen by following the relatively standard practice in the literature. We let $\sigma = 1.5$ and $\varepsilon = 1$,²⁶ the one-year depreciation rate is set at $\delta = 0.058$, and we choose $\frac{\alpha}{\alpha+\theta}$ to match an aggregate share of capital of 0.33.

We are thus left with the six parameters that are more specific to our study: $\alpha + \theta$, κ_{NT} , κ_T , η , γ , and β .²⁷ We calibrate them to match six relevant moments in the U.S. data as describe in the first column of Table 2, and suggested by the discussion of Section 3.1: i) the average size of establishments in non-tradables (15) and tradables (48), ii) the employment share of the top decile of establishments (0.63); iii) the share of income generated by the top five percentile of earners (0.30); iv) the exit rate of establishments (0.10); vi) and the real interest rate (0.05).

The identification of these six parameters follows the basic logic discussed in the previous section. We calibrate the fixed costs, $\kappa_{NT} = 0$ and $\kappa_T = 5.3$, to match the average employment per establishment in the non-tradable and tradable sectors of 15 and 48, respectively. Given the returns to scale, $\alpha + \theta$, we choose the tail of the distribution of entrepreneurial ideas, $\eta = 5.3$, to match the share of employment accounted by the top 10% of establishments, 0.63. We can then infer $\alpha + \theta = 0.8$ from the income share of the top five percentile of earners; top earners are mostly entrepreneurs (both in the US data and in the model), and $\alpha + \theta$ controls the share of income going to the entrepreneurial input. The resulting share of entrepreneurial income (0.2) is comparable to calibrated markups in isomorphic monopolistic competition models. The parameter $\gamma = 0.89$ leads to an annual establishment exit rate of 10% in the model. This is roughly consistent with job destruction rates in the U.S. reported by Davis, Haltiwanger, and Schuh (1996) and plant exit rates in developing countries reported by Tybout (2000), although both studies focus on the manufacturing sectors. Finally, the model requires a discount factor $\beta = 0.92$ to match the interest rate of five percent.

²⁶The intratemporal elasticity is within the range of 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.

²⁷As is common in heterogeneous agents model with financial frictions, the discount rate must be jointly calibrated with the parameters determining the stochastic process of (entrepreneurial) income.

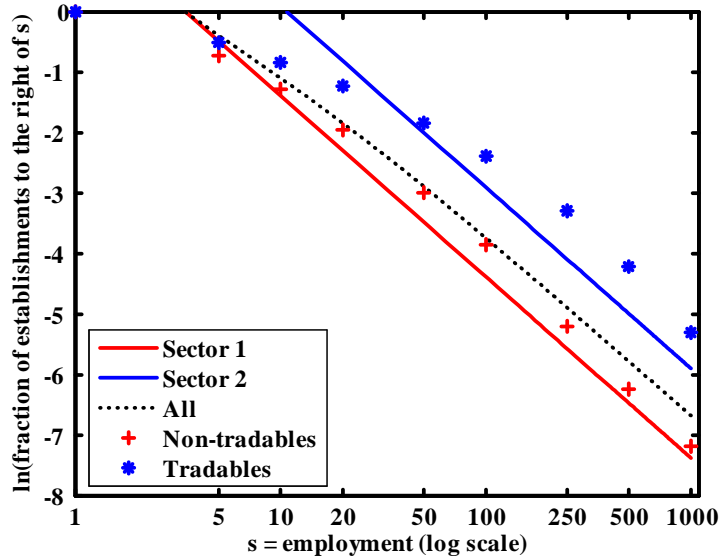


Figure 2: Size distribution of establishments across sectors, in the data (* and +) and model (solid and dash lines).

Target	US Data	Model	Parameter
top 10% employment share	0.63	0.63	$\eta = 5.3$
top 5% income share	0.30	0.29	$\alpha + \theta = 0.8$
avg. scale in NT sector	15	15	$\kappa_1 = 0$
avg. scale in T sector	48	46	$\kappa_2 = 2$
Exit rate	0.10	0.10	$\gamma = 0.89$
Interest rate	0.05	0.05	$\beta = 0.92$

Table 2: Calibration

Figure 2 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 assumption that productivities for both sectors are drawn from the same Pareto distribution also generates the similar slopes of the right tail in the two sectors. The model cannot capture the initial concavity in distribution of establishment within a sector, however, presumably due to our abstracting from within-sector heterogeneity in the setup costs.

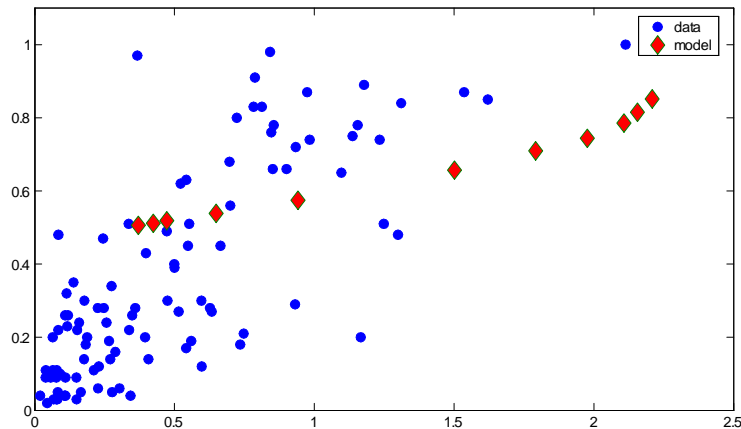


Figure 3: External finance and GDP ratio (horizontal axis) vs. Per-capita GDP relative to the US (vertical axis)

4.2 Baseline Results

[preliminary]

In this section we show the quantitative effects of financial frictions on the level of per-capita income, aggregate TFP, capital intensity and relative productivity and prices across sectors. We vary the parameter ϕ , our measure of financial frictions, in order to generate a range of values for external finance/GDP consistent to what is observed in the data: averaging 0.1 for the lowest quantile and 2.1 for the top quintile of the per-capita income distribution. External finance/GDP is monotonically decreasing in ϕ . In these simulations, we generate 6 values with ϕ ranging from 0.6 to 0.9, which generate variation in external finance/GDP ratios from XX to XX.

Figure 5 shows the effect of financial frictions on output per worker in our model economy (diamonds), and compares predictions of the model with the observed relationship between external finance and output per worker (circles). Output per worker in each economy is measured relative to that of the US. In our model, the variation in financial frictions can explain output per worker levels as low as 50 percent of the U.S. level. This roughly accounts for the difference in development between a country like Malaysia and the U.S. While this does not explain the bulk of the differences between the poorest countries, e.g., Nigeria and the US, we consider this to be a relatively large magnitude, particularly so given that we are only a single factor.

Figure 6 uses a log-log scale to plot the relative price of tradables to non-tradables, p_T/p_{NT} ,

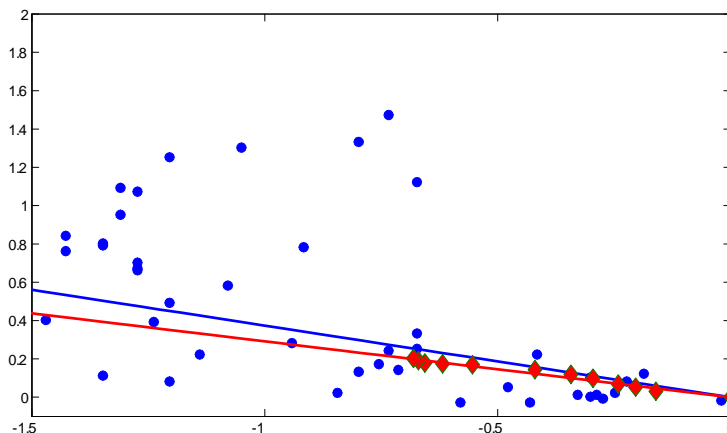


Figure 4: Log Per-capita GDP relative to the US (horizontal axis) vs. $\text{Log } p_T/p_{NT}$ (vertical axis)

against per-capita GDP (both are measured relative to the US values). The diamonds represent the model simulations. The circles represent the data. Our baseline calibration explains nearly all (XX%) of the implied cross-country elasticity between relative TFP and income per capita, although the model produces only about half of the variation in income per capita.²⁸ This result suggest that it remains important to explore for yet additional driving forces of output per worker that also affect the relative productivity of tradables to non-tradables.

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 overall effects of financial frictions on output are substantial. Simply varying the single parameter ϕ to generate the range of external financing/GDP ratios observed in the data leads to a XX-fold difference in output per worker across the sample, as compared to a XX-fold difference in the data. The channels are two-fold. XX% is explained by the lower aggregate TFP in countries with deep frictions. The effect of lower TFP alone on capital accumulation is XX%. The remaining XX% comes from lower levels of steady-state capital/output ratios due to the higher relative price of capital.]

So far we have review the quantitative implications of the model for per-capita income, relative prices, aggregate productivity and capital intensity. Next, we explore the various underlying driving forces of these aggregate results. In particular, we discuss how financial frictions affect the sectoral distribution of productivity of entrepreneurs, their numbers and size distribution.

²⁸Our model explains about half of the elasticity of relative prices with respect to external finance.

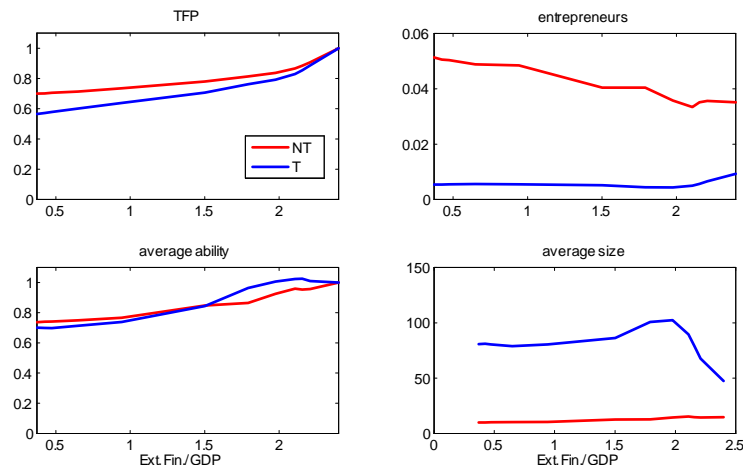


Figure 5: Underlying Determinants of Productivity across Sectors

Panel 1 of Figure 7 plot sectoral TFP, A_T and A_{NT} , versus external finance/GDP.²⁹ TFP is increasing with financial intermediation in both sectors, but particularly so for the tradable sector. In our economy with the worst credit markets (external finance/GDP of XX) the TFP of the tradable sector is XX% lower than that of the benchmark economy. For the non-tradable sector TFP decreases up to XX%. The second panel shows the average entrepreneurial ability z for both the tradable and non-tradable sectors as a function of external finance to GDP. A large share of the absolute trends in TFP are explained by changes in average entrepreneurial ability, although the average quality of entrepreneur does not explain the relative performance of the two sectors.

Of course, not only the average ability, but also the total number of entrepreneurs, the size of establishments, and the allocation of capital to talent are also distorted by financial frictions. The third and fourth panel of Figure 7 shows how the number of entrepreneurs and the average size of establishments vary with financial intermediation in the two sectors. The third panel presents the number of entrepreneurs, which decreases with financial intermediation in the non-tradable sector because of the general equilibrium effects, mainly the increase in wages. For the tradable sector, the effects of fewer high ability, low wealth individuals, but more high wealth, low ability individuals roughly cancel, and the overall number of entrepreneurs first decreases slightly but later increases significantly for very high levels of financial intermediation. The mainly positive effects of financial

²⁹Here we have used the standard sectoral production function, $Y_s = A_s K_s^{1/3} L_s^{2/3}$, to do the TFP accounting. In the model, we have calculated sectoral TFP as $A_T/A_{NT} = \left(Y_T / \left(K_{NT}^{1/3} L_{NT}^{2/3} \right) \right) / \left(Y_{NT} / \left(K_{NT}^{1/3} L_{NT}^{2/3} \right) \right)$.

intermediation on the number of entrepreneurs in the tradable sector reflects the fact that there is a large direct effect of frictions on the financing of fixed cost and scale in that sector. As we said, in the non-tradable sector the main effect is a positive general equilibrium as the wage decreases with financial frictions.

The U-shape in entrepreneurs is more evident in the forth panel, which plots the average establishment size. At very low levels of financial intermediation, the average scale of tradable establishments is increasing, mainly due to the increasing average ability. Given the GE effects, however, his trend reverses at mild levels of intermediation (external finance/GDP of around 1.5) because so that in the most intermediated economies, the average establishment size is actually smaller. In contrast, the average size of non-tradable establishments is monotonically increasing in financial intermediation.

4.3 Robustness

To do: We examine the robustness of our results to the consideration of set-up costs and the choices of $(1 - \alpha - \theta)$ and γ .

4.4 A Testable Implication

The simulations confirm the intuition that financial frictions are relatively more harmful to TFP in the high fixed 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-fixed cost sectors. This prediction stems not only from the direct effect of financial frictions on entry decisions, but also from the resulting general equilibrium effect on wages, capital rental rates, and output prices. Given low wages, (very) small-scale entrepreneurship is more desirable because the opportunity cost (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.

As mentioned earlier, in the real world, many potential country-specific distortions affect the absolute scales of establishments, particularly in developing countries. (Hsieh and Klenow, 2007b, and Guner, Ventura and Yi, 2007, highlight the importance of other distortions, for example.) Still, the differential distortion leads to a testable implications that the relative average scale of the

tradable sector is decreasing with income (or financial frictions).

4.4.1 Cross-country Analysis of Relative Scale

Evaluating this implication 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.³⁰ Second, the OECD SSIS data is less well documented but 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).³¹ Korea and Turkey provide establishment data, while the others provide enterprise data. Given our focus on financing, we drop government, 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 weighted 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.³² 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 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

³⁰Construction, mining, transportation, FIRE, telephone, postal service, electricity and water are all collected at the firm level in Mexico.

³¹The data is for 2002. When not available we use 2001 or 2003. Data on three additional advanced economies (Australia, Canada, Japan) and one additional poorer country (Mexico) lacked coverage of broad sectors of the economy.

³²GDP 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.

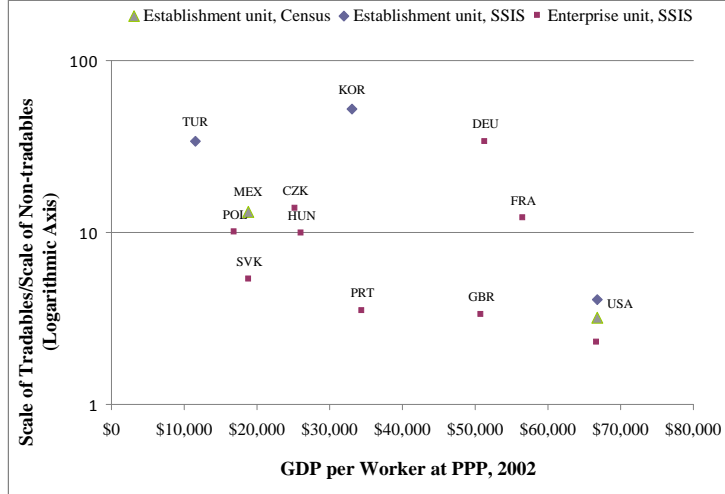


Figure 6: Relative Scale vs. Output per Worker, 12 Countries

for Mexico is much flatter than in the numerical examples.

The squares show that the relative scale of tradables *enterprises* also is larger in poor countries than in the U.S. The magnitude of the relationship is 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.

4.4.2 U.S. vs. Mexico Case Study

Data for the U.S. and Mexico are sufficient for a closer, more detailed analysis. We use Mexico's 1998 National Survey of Microenterprises (ENAMIN for its Spanish initials) to impute corrections that make the U.S. and Mexican data fully comparable, even on a detailed level. These corrections include adjustments to remove non-employers, which are included in the Mexican Census but not the U.S., and adjustments to add small-scale entrepreneurs that lack a fixed location, which are included in the U.S. (though presumably unimportant) but not in Mexico where they play an important role. We analyze data at the 4-digit level dropping industries that have a high level of

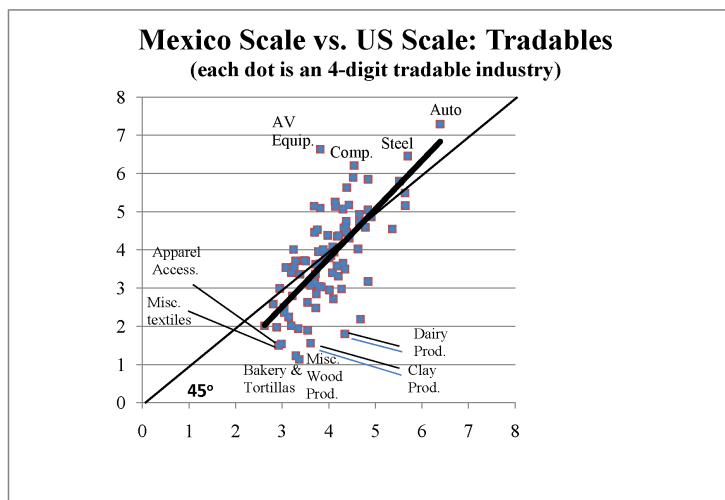


Figure 7: Log scale in the US (horizontal axis) vs. Log scale in Mexico (vertical axis)

government involvement or provision.³³

The average establishment size is substantially smaller in Mexico than in U.S. (7 workers vs. 16 workers), particularly in the typical suspects of non-tradables: retail, transportation, and construction. Comparison of non-tradables at a more detailed level is not possible, unfortunately, since the U.S. and Mexican classification schemes do not correspond.

Tradables, however, show perfect correspondence, a goal of the NAICS system. In the tradable sector, many industries tend to have larger establishments in Mexico. Figure 4 plots the log average scale of establishments in Mexico vs. the log average scale of establishments in the U.S. for 88 4-digit tradable (i.e., manufacturing and mining) industries. The data show a relationship that is clearly steeper than the 45-degree line. That is, the industries that are large scale in the U.S. are even larger scale in Mexico, while those that are smaller scale in the U.S. are still smaller in Mexico. The regression coefficient is 1.27 (standard error=0.14).

Finally, we show that the difference between the log average scale in Mexico and log average scale in the U.S. is related to a well-known, industry-specific measure of dependence on external

³³More precisely, we drop health, education, petroleum mining and transportation, urban and intercity passenger rail, air transportation, gambling and casinos, and some social service industries in which government establishments constitute at least 50 percent of all establishments.

finance. That is, using COMPUSTAT 2007 data for the U.S., we reconstruct Ranjan and Zingales (1998)'s measures of industry-specific financial dependence³⁴, $FINDEP_i$, using the 1993-2003 period. $FINDEP_i$ has a mean of -0.02 across industries with a standard deviation of 0.33.³⁵ We estimate the following significant regression equation:

$$\log(scale_{mex,i}) - \log(scale_{US,i}) = \underset{0.11}{-0.10} + \underset{0.34}{1.25} FINDEP_i$$

Thus, the pattern in differential scale tends to be closely related to technology-specific external finance requirements.

5 Conclusions

The paper has developed a quantitative theory linking countries levels of financial development to their per-capita GDP, aggregate TFP, 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.

Financial frictions are one of potentially various distortions to scale. A central theme in this

³⁴Ranjan and Zingales' measure the ratio of the difference between capital investment (Compustat #128) and cash flow (Compustat #110, or the sum #123, 125, 126, 106, 213, and 217, for format code 7).

³⁵They take the total capital investment and total cash flow over the sample period to compute firm-specific numbers, and then apply the median value within an industry as the industry-specific value. Although they use 3-digit industries, and so they have larger sample sizes, both the summing and the use of medians is needed to negate the influence of outliers in noisy data. At 4-digits the influence of outliers is even more problematic. We require these ratios to be between -1 and 1, which dictates dropping six industries: leather& hide tanning (-2.5); other leather industries (-1.8); paints, coatings, & adhesives (-1.3); pharmaceuticals & medicine (5.6), soap, cleaning compounds, & toilet preparations (8.4); and not elsewhere classified furniture & related products (57.4). Results are robust to inclusion of the negative outliers, but not the positive ones, and only pharmaceuticals & medicine is a quantitatively important industry.

paper is that differences in technologies that are reflected in sectoral variation in the scale are a key dimension that distinguishes sectors. On the light of this observation, we view the study of other frictions distorting the scale of establishments, e.g., size dependent policies (Guner et al., 2007), barriers to entry (...), as promising avenues for future research.

Proof of Proposition 1. We say that the rental of capital k is enforceable iff³⁶

$$\tilde{v}(k; a, z) \geq v^d((1 - \phi)(k + p\kappa), z) \quad (7)$$

where $\tilde{v}(k; a, z)$ is the value of an entrepreneurs with wealth a and ability z that operates in sector s at a scale k :

$$\begin{aligned} \tilde{v}(k; a, z) &= \max_{c, a'} \{u(c) + \beta [\gamma v(a', z) + (1 - \gamma) E_{z'} v(a', z')]\} \\ &s.t. \\ c + a' &\leq \max_l \{zf(k, l) - wl\} - Rk - (1 + r)\kappa + (1 + r)a \end{aligned}$$

and $v^d(a^d, z)$ is the value of a defaulting entrepreneur with ability z who gets to keep defaulted assets $a^d = (1 - \phi)(k + \kappa)$:

$$\begin{aligned} v^d(a^d, z) &= \max_{c, a'} \{u(c) + \beta [\gamma v(a', z) + (1 - \gamma) E_{z'} v(a', z')]\} \\ &s.t. \\ c + a' &\leq \max_{l, \tilde{k} \leq a^d - \kappa} \{zf(\tilde{k}, l) - \delta\tilde{k} - wl - \kappa\} + a^d \end{aligned}$$

It is straightforward to see that $\tilde{v}(k; a, z) \geq v^d((1 - \phi)(k + \kappa), z)$ iff

$$\begin{aligned} y(k, a, z) &= \max_l \{zf(k, l) - wl\} - Rk - (1 + r)\kappa + (1 + r)a \\ &\geq \max_{l, \tilde{k} \leq a^d - \kappa} \{zf(\tilde{k}, l) - \delta\tilde{k} - wl - \kappa\} + a^d \\ &= y^d(k, z; \phi). \end{aligned} \quad (8)$$

In what follows, we restrict the analysis to entrepreneurs that would be profitable if operating at the unconstrained scale, i.e., $\max_{k, l} \{zf(k, l) - wl - Rk\} > 0$. We define $k^u(z)$ to be the optimal choice of capital in the previous problem.

For $\phi = 0$ 8) simplifies to $a \geq k + \kappa$, implying that external finance is not feasible, i.e., $\bar{k}(a, z; \phi) = a + \kappa$. For $\phi = 1$ the unconstrained scale is enforceable independent of the wealth. In this case

³⁶In the following argument we abstract from the index s and set $p_s = 1$.

we define $\bar{k}(a, z; \phi) = k^u(z)$ for all a .³⁷ Moreover, for $\phi > 0$ and $a \geq \underline{a}(\phi)$, where $\underline{a}(\phi)$ solves $y(k^u(z), \underline{a}(\phi), z) = y^d(k^u(z), z; \phi)$, we know that $k^u(z)$ is enforceable, i.e., $y(k^u(z), a, z) > y^d(k^u(z), z; \phi)$, and let $\bar{k}(a, z; \phi) = k^u(z)$. In these case it is straightforward to see that $\bar{k}(a, z)$ is weakly increasing in a and z .

For intermediate values of ϕ and a , $\phi \in (0, 1)$ and $a < \underline{a}(\phi)$, we define $\bar{k}(a, z; \phi)$ to be the largest solution to the following equation satisfying $k < k^u(z_s)$:

$$y(k, a, z) = y^d(k, z; \phi).$$

Notice that $\partial y(\bar{k}(a, z; \phi), a, z) / \partial k < \partial y^d(\bar{k}(a, z; \phi), z; \phi) / \partial k$ since for $\phi \in (0, 1)$ and $a < \underline{a}(\phi)$ both $y(k, a, z)$ and $y^d(k, z; \phi)$ are continuously differentiable functions of k , $y(k^u(z), a, z) < y^d(k^u(z), z; \phi)$, and $\bar{k}(a, z; \phi)$ is assumed to be the largest solution to the following equation satisfying $k < k^u(z_s)$.

That $\bar{k}(a, z; \phi)$ is strictly increasing in a follows immediately from the fact that $y(k, a, z)$ is strictly increasing in a and that at $k = \bar{k}(a, z)$ $\partial y(\bar{k}(a, z; \phi), a, z) / \partial k < \partial y^d(\bar{k}(a, z; \phi), z; \phi) / \partial k$. Similarly, that $\bar{k}(a, z; \phi)$ is strictly increasing in ϕ follows from the fact that $y^d(k, z; \phi)$ is strictly decreasing in ϕ . Finally, that $\bar{k}(a, z; \phi)$ is strictly increasing in z follows from $f(k, l(k)) > f(a^d - \kappa, l(a^d - \kappa))$.

■

Proof of Proposition 2. In perfect credit economy, selection of individuals into occupations and sectors are determined by their entrepreneurial ability and relative prices. In particular, there exist two threshold ideas z_s , $s = NT, T$, and a function $z_s(z_{-s})$, $s = NT, T$, $-s = T, NT$, dividing the space of entrepreneurial ideas (z_{NT}, z_T) into workers and entrepreneurs in the NT and T sectors. These thresholds are defined by the following three indifference conditions:

$$(p_s \hat{z}_s)^{\frac{1}{1-\alpha-\theta}} \left(\frac{\alpha}{R}\right)^{\frac{\alpha}{1-\alpha-\theta}} \left(\frac{\theta}{w}\right)^{\frac{\theta}{1-\alpha-\theta}} (1-\alpha-\theta) = w + p_s \kappa_s, \quad s = NT, T \quad (9)$$

and

³⁷Without loss of generality we restrict to rental limits that are less or equal to the optimal scale, $\bar{k}(a, z; \phi) \leq k^u(z)$.

$$\begin{aligned}
& (p_s z_s(z_{-s}))^{\frac{1}{1-\alpha-\theta}} \left(\frac{\alpha}{R}\right)^{\frac{\alpha}{1-\alpha-\theta}} \left(\frac{\theta}{w}\right)^{\frac{\theta}{1-\alpha-\theta}} (1-\alpha-\theta) - p_s \kappa_s \\
&= (p_{-s} z_{-s})^{\frac{1}{1-\alpha-\theta}} \left(\frac{\alpha}{R}\right)^{\frac{\alpha}{1-\alpha-\theta}} \left(\frac{\theta}{w}\right)^{\frac{\theta}{1-\alpha-\theta}} (1-\alpha-\theta) - p_{-s} \kappa_{-s}
\end{aligned}$$

Net output of sector s equals

$$Y_s = N \int_{\hat{z}_s}^{\infty} \int_0^{\hat{z}_{-s}(z_s)} z_s A_s k(z)^\alpha l(z)^\theta \mu(dz) - \kappa_s N \int_{\hat{z}_s}^{\infty} \int_0^{\hat{z}_{-s}(z_s)} \mu(dz).$$

Using $k(z) = \frac{z^{\frac{1}{1-\alpha-\theta}} K_s}{Z_s^{\frac{1}{1-\alpha-\theta}} N}$ and $l(z) = \frac{z^{\frac{1}{1-\alpha-\theta}} L_s}{Z_s^{\frac{1}{1-\alpha-\theta}} N}$ (these follow from the first order conditions of the firms' maximization problem),

$$\begin{aligned}
Y_s &= N \int_{\hat{z}_s}^{\infty} \int_0^{\hat{z}_{-s}(z_s)} z_s A_s \left[\frac{z_s^{\frac{1}{1-\alpha-\theta}} K_s}{Z_s^{\frac{1}{1-\alpha-\theta}} N} \right]^\alpha \left[\frac{z_s^{\frac{1}{1-\alpha-\theta}} L_s}{Z_s^{\frac{1}{1-\alpha-\theta}} N} \right]^\theta \mu(dz) - \kappa_s N \int_{\hat{z}_s}^{\infty} \int_0^{\hat{z}_{-s}(z_s)} \mu(dz) \\
&= \frac{A_s N^{1-\alpha-\theta} K_s^\alpha L_s^\theta}{Z_s^{\frac{\alpha+\theta}{1-\alpha-\theta}}} \int_{\hat{z}_s}^{\infty} \int_0^{\hat{z}_{-s}(z_s)} z_s^{\frac{1}{1-\alpha-\theta}} \mu(dz) - \kappa_s N \int_{\hat{z}_s}^{\infty} \int_0^{\hat{z}_{-s}(z_s)} \mu(dz)
\end{aligned}$$

or

$$Y_s = A_s N^{1-\alpha-\theta} K_s^\alpha L_s^\theta Z_s - \kappa_s N \int_{\hat{z}_s}^{\infty} \int_0^{\hat{z}_{-s}(z_s)} \mu(dz) \quad (10)$$

where $Z_s = \left[\int_{\hat{z}_s}^{\infty} \int_0^{\hat{z}_{-s}(z_s)} z_s^{\frac{1}{1-\alpha-\theta}} \mu(dz) \right]^{1-\alpha-\theta}$.

Assuming $\mu(dz) = \eta^2 (z_{NT} z_T)^{-(\eta+1)}$ and that entrepreneurs are a small fractions of the populations, i.e., \hat{z}_s is large, $s = NT$, T , we obtain

$$Z_s = \left[\int_{\hat{z}_s}^{\infty} \int_0^{\hat{z}_{-s}(z_s)} z^{\frac{1}{1-\alpha-\theta}} \mu(dz) \right]^{1-\alpha-\theta} \approx \left[\int_{\hat{z}_s}^{\infty} z^{\frac{1}{1-\alpha-\theta}} \eta z_s^{-(\eta+1)} dz_s \right]^{1-\alpha-\theta}$$

and

$$\int_{\hat{z}_s}^{\infty} \int_0^{\hat{z}_{-s}(z_s)} \mu(dz) \approx \hat{z}_s^{-\eta}.$$

Using (9), $\frac{\alpha}{R} = \frac{K_s^{1-\alpha}}{L_s^\theta} \frac{1}{p_s Z_s}$ and $\frac{\theta}{w} = \frac{L_s^{1-\theta}}{K_s^\alpha} \frac{1}{p_s Z_s}$ we can obtain

$$\hat{z}_s = \left\{ \frac{\left(\kappa_s + \frac{w}{p_s} \right) \left[\frac{(1-\alpha-\theta)}{\eta(1-\alpha-\theta)-1} \eta \right]^{\alpha+\theta}}{(1-\alpha-\theta) A_2 N^{-\alpha-\theta} K_s^\alpha L_s^\theta} \right\}^{\frac{1}{1+\eta(\alpha+\theta)}}. \quad (11)$$

Substituting into (10)

$$Y_s = A_s N^{\frac{1}{1+\eta(\alpha+\theta)}} K_s^{\frac{\alpha\eta}{1+\eta(\alpha+\theta)}} L_s^{\frac{\theta\eta}{1+\eta(\alpha+\theta)}}$$

where

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

■

Proof of Proposition 3. From the first order conditions of an entrepreneur of productivity z and that of the marginal entrepreneur (\hat{z}_s) we obtain

$$l(z) = \left(\frac{z}{\hat{z}_s} \right)^{\frac{1}{1-\alpha-\theta}} l(\hat{z}_s).$$

Thus,

$$\begin{aligned} \Pr \left[\tilde{l}_s > l \right] &= P \left[\left(\frac{z}{\hat{z}_s} \right)^{\frac{1}{1-\alpha-\theta}} l(\hat{z}_s) > l \right] \\ &= P \left[z > \left(\frac{l}{l(\hat{z}_s)} \right)^{1-\alpha-\theta} \hat{z}_s \mid z \geq \hat{z}_s \right] \\ &= \left(\frac{l(\hat{z}_s)}{l} \right)^{\eta(1-\alpha-\theta)}. \end{aligned}$$

The aggregate distribution of employment is then given by a mixture of Pareto:

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

for $l \geq l(\hat{z}_1)$. Finally, by integrating $l(z) = \frac{z^{\frac{1}{1-\alpha-\theta}} L_s}{Z_s^{\frac{1}{1-\alpha-\theta}} N}$, we obtain that the average employment per establishment in sector s equals

$$l_s = \frac{L_s}{N(1-\mu(\hat{z}_s))}. \quad (12)$$

The optimal allocation of labor (L_s) and establishments (n_s) to sector s implies

$$\theta p_s N^{1-\alpha-\theta} Z_s K_s^\alpha L_s^{\theta-1} = w$$

and

$$(1 - \alpha - \theta) p_s N^{-\alpha-\theta} Z_s K_s^\alpha L_s^\theta = p_s \kappa_s (1 - \mu(\hat{z}_s)) + w \mu(\hat{z}_s) \quad (13)$$

Taken the ratio of these two conditions implies

$$\frac{1 - \alpha - \theta}{\theta} \frac{L_s}{N(1 - \mu(\hat{z}_s))} = (1 - \gamma) \frac{p_s \kappa_s}{w} + \frac{\mu(\hat{z}_s)}{1 - \mu(\hat{z}_s)}. \quad (14)$$

Substituting (13) into (11) we obtain

$$\hat{z}_s = \left\{ \frac{\left(\kappa_s + \frac{w}{p_s} \right) \left[\frac{(1-\alpha-\theta)}{\eta(1-\alpha-\theta)-1} \eta \right]^{\alpha+\theta}}{\frac{p_s \kappa_s (1 - \mu(\hat{z}_s)) + \frac{w}{p_s} \mu(\hat{z}_s)}{Z_s}} \right\}^{\frac{1}{1+\eta(\alpha+\theta)}}$$

rearranging

$$\frac{p_s \kappa_s}{w} + \frac{\mu(\hat{z}_s)}{1 - \mu(\hat{z}_s)} = \left[\frac{p_s \kappa_s}{w} + \frac{\mu(\hat{z}_s)}{1 - \mu(\hat{z}_s)} \right] \frac{\eta(1 - \alpha - \theta) - 1}{\eta(1 - \alpha - \theta)} \quad (15)$$

using (12), (14) and (15) we obtain the desired expression.

$$\frac{l_s}{l_{s'}} = \frac{\frac{p_s \kappa_s}{w} + 1}{\frac{p_{s'} \kappa_{s'}}{w} + 1}$$

■

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