FINANCE AND DEVELOPMENT:
A TALE OF TWO SECTORS

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ABSTRACT

Income differences across countries primarily reflect differences in total factor productivity (TFP). More disaggregated data show that the TFP gap between rich and poor countries varies systematically across industrial sectors of the economy: Poor countries are particularly unproductive in tradable and investment goods sectors. In this paper, we develop a quantitatively-oriented framework to explain such cross-country patterns in aggregate and sectoral TFP. We start by documenting that an important distinction between sectors is their average establishment size. For example, establishments in tradable and investment goods sectors operate at much larger scales than those in the non-tradable sector. In our model, sectors with larger scales of operation have more financing needs, and are hence disproportionately affected by financial frictions. Our quantitative exercises show that financial frictions account for a substantial part of the observed cross-country patterns in TFP, both at the aggregate and at the sectoral level. Our model also has novel implications for the impact of financial frictions on the relative scale between the tradable and the non-tradable sectors, which are shown to be consistent with the data.

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1   Introduction

Income per capita differences across countries are primarily accounted for by low total factor productivity (TFP) in poor countries (Klenow and Rodríguez-Clare, 1997; Hall and Jones, 1999). More disaggregated data show that the TFP gap between rich and poor countries varies systematically across industrial sectors of the economy. For instance, poor countries are particularly unproductive in producing tradables and investment goods (Hsieh and Klenow, 2007b).[1] In this paper, we first document that an important distinction between sectors is their average establishment size: Establishments in tradable and investment goods sectors are on average much larger than those in the non-tradable sector. Our premise is that such scale differences reflect sectoral differences in the technology used by their production units. We propose and quantify a theory of aggregate and sectoral TFP based on cross-sector differences in the optimal scale of establishments and cross-country differences in financial development.

Financial frictions affect productivity of sectors by distorting the allocation of capital among heterogeneous establishments and also their entry and exit decisions. In our model, consistent with the data, those sectors in which poor countries are particularly unproductive—e.g. investment goods and tradable goods sectors—differ from others in that their establishments operate most efficiently at larger scales. Larger scales come with more financing needs, rendering the large-scale sector disproportionately more vulnerable to financial frictions. In the large-scale sector, it takes longer for a talented-but-poor entrepreneur to self-finance the capital needed for operating at a profit-maximizing scale. The selection of entrepreneurs into the large-scale sector is also based more on individuals' wealth (or self-financing capability) and less on their entrepreneurial talent. These effects explain why, for example, tradable and investment goods sectors (i.e. large-scale sectors) are particularly unproductive relative to non-tradable and consumption goods sectors (i.e. small-scale sectors) in countries with underdeveloped financial markets.

More specifically, we study an economy with two sectors that differ in their per-period fixed costs required of running an establishment. Differences in fixed costs lead to differences in the optimal scale of establishments. In the model, individuals choose in each period whether to operate an establishment—become an entrepreneur—or to supply labor for a wage. Individuals differ in their productivity as an entrepreneur and in their wealth, with the latter being endogenously determined by forward-looking saving decisions. The productivity of entrepreneurs evolves stochastically, generating the need to reallocate factors of production from previously-productive to currently-productive entrepreneurs.

Financial frictions hinder this reallocation process. We model financial frictions in the

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[1]Balassa (1964) and Samuelson (1964) are the classic citations for tradables and non-tradables. Jones (1994), Eaton and Kortum (2001), and Herrendorf and Valentinyi (2006) are more recent contributions.

form of collateral constraints on capital rental, which ultimately arise from imperfect enforceability of contracts. In an economy with perfect credit markets, sectoral and occupational choices are based on comparative advantage: The most talented individuals become entrepreneurs and the allocation of capital equalizes marginal products of capital across sectors and establishments. With financial frictions in the form of collateral constraints, entrepreneurs' production and individuals' occupational decisions are constrained by their available wealth. This leads to distortions along three margins that lower sectoral and aggregate TFP. First, for a given set of heterogeneous production units in operation, financial frictions distort the allocation of capital among them (misallocation of capital). Second, for a given number of production units in operation, financial frictions distort the allocation of talents into entrepreneurship and into sectors, with talented-but-poor individuals delaying their entry and incompetent-but-rich entrepreneurs remaining in business for longer (misallocation of talent). Third, financial frictions distort the number of production units for a given distribution of entrepreneurial talent in an economy.

We use our model to provide a quantitative analysis of the cross-country pattern in aggregate and sectoral TFP. We discipline the analysis by requiring that a benchmark model with well-functioning financial markets matches US data on the establishment size distribution across and within sectors (e.g., average scale and thick right-tails of broadly-defined sectors), the dynamics of establishments, and income concentration. We then employ data on the use of external financing to calibrate the variation in financial development across countries and quantify its effect. Finally, we use cross-country data on the establishment size distribution across sectors as over-identifying restrictions and test additional implications of our model.

We find that financial frictions have sizable effects on per-capita income, aggregate TFP and sectoral TFP.

The variation in financial development can explain a factor-of-two difference in per-capita income across countries, or almost 80 per cent of the difference in per-capita income between Mexico and the US. One thing to note is that the agricultural sector is not modeled or analyzed here. This factor-of-two difference goes a long way in explaining the factor-of-five difference in non-agricultural per-capita income between the richest fifth percentile and the poorest fifth percentile of countries. Consistent with the consensus view in the literature, most of per-capita income differences in our model are accounted for by lower TFP in less developed economies. For example, our model predicts that a country ranking in the bottom third of the world in terms of financial development will have TFP at least 40 per cent below that of the US.

Financial frictions generate particularly low TFP in sectors with large scales of operation, e.g. the tradable and investment goods sectors. While TFP declines by up to 30 per cent in the small-scale sector, TFP in the large-scale sector declines by more than 50 per cent. These

differential effects on productivity lead to a large impact on relative prices, with a higher relative price of goods produced with large-scale technologies in financially-underdeveloped economies. For instance, the model accounts for almost all (95 per cent) of the observed elasticity of the relative price of tradables to non-tradables with respect to per-capita income (the Balassa-Samuelson effect).

Our quantitative analysis provides a clear decomposition of the main margins distorted by financial frictions. While there is a significant role for the misallocation of capital in explaining the absolute differences in TFP across countries, the misallocation of talent into entrepreneurship and into sectors has a prominent role in explaining the particularly large differences in the TFP of the large-scale sector. Whereas the misallocation of capital explains 90 per cent of the lower TFP in the small-scale sector, it only explains half of the TFP differences in the large-scale sector. It is the misallocation of talent that accounts for the other half of the TFP differences in the large-scale sector. The distortion on the number of entrepreneurs per se has only minor impact on productivity in either sector.

Our theory is built on two premises: 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—underdevelopment in poor countries in particular, has been well established in the literature. King and Levine (1993a) and Beck et al. (2000) show that aggregate measures of credit and financial development are closely correlated with output per capita across countries, while La Porta et al. (1998) document that these macro indicators are strongly related to underlying institutional differences such as the enforcement of contracts, creditor protection, and so on. Banerjee and Duflo (2005) review the literature documenting micro-level evidence for credit constraints in poor countries and for the resulting misallocation of capital. In his detailed analysis of Thailand, Townsend (2006) links observed misallocation to micro-level credit constraints and shows how their relaxation through financial development leads to faster economic growth.

One empirical contribution of our paper is to establish the second premise: cross-sector differences in scale, defined as workers per establishment. Using detailed sector-level data from the OECD countries (the US in particular), we document that the average size of establishments varies substantially across broadly-defined sectors. For example, the average establishment in the tradable sector is three times as large as that in the non-tradable sector. This sectoral difference in establishment size is robustly observed in a wide range of countries. Furthermore, using price data from a cross-section of countries, we show that, at a more disaggregate level, poor countries are particularly unproductive in industries with larger scales.

In our model, financial frictions have differential impacts on sectors with different scales

because our notion of scale (establishment size) translates directly into financing needs. The most widely-used empirical metric of financing needs is "external dependence" constructed by Rajan and Zingales (1998). We compute the external dependence for broadly-defined sectors in the US, and find that sectors with larger scales (manufactured consumption and equipment investment, which compose the tradable sector) also have larger external dependence, providing additional support for our mechanism.

Our mechanism for differential impact of financial frictions across sectors produces a novel and testable implication on the relative scale of sectors in an economy with financial frictions. Financial frictions, together with the resulting higher relative price of the large-scale sector output and lower wages in the equilibrium, lead to too many entrepreneurs with too small establishments in the sector with small fixed costs, and too few entrepreneurs with too large establishments in the sector with large fixed costs. Using OECD data on 11 countries in different stages of economic development, we show that the relative size of establishments/enterprises in the large-scale, tradable sector to those in the small-scale, non-tradable sector is indeed larger in less developed economies, consistent with our model prediction. We supplement this evidence with a detailed case study of the US and Mexico, using data on absolute scale from their respective Economic Census data (based on the common, and hence comparable, North American Industrial Classification System) and a survey of small businesses in Mexico (which provides data on small-scale, mobile, and informal entrepreneurs). We find empirical support for our model prediction on how financial frictions have differential impacts on the absolute scale of different sectors. Average scale in Mexico is substantially smaller overall, but within the tradable sector, industries with large-scale establishments in the US tend to have even larger establishments in Mexico. To the best of our knowledge, these empirical findings at the sector level have not been documented in the literature.[2]

Related Literature   This paper contributes to a vast literature relating financial frictions and entrepreneurship to development, including theoretical contributions by: Banerjee and Newman (1993), King and Levine (1993b), Aghion and Bolton (1997), Piketty (1997), and Lloyd-Ellis and Bernhardt (2000); and relatively fewer quantitatively-oriented macro studies by: Giné and Townsend (2004), Amaral and Quintin (2005), Caselli and Gennaioli (2005), Jeong and Townsend (2007), and Buera and Shin (2008).[3]

This paper is more closely related and complementary to two others in the literature

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[2]Our findings do conform to the conventional wisdom of a "missing middle" in poor countries (Tybout, 2000).

[3]This paper builds on Buera and Shin (2008) by extending their analysis to a multi-sector environment with fixed-cost technologies. The effects of financial frictions on per-capita income are two-thirds larger in an economy with fixed-cost technologies relative to the environment in Buera and Shin that abstracts from sectoral differences in fixed costs and scale.

that emphasize the differential effects of financial frictions on different industries. Rajan and Zingales (1998), an empirical paper, creates an index of dependence on external sources of financing for various manufacturing industries, and tests whether industries that are particularly dependent on financing grow relatively faster in countries with more developed financial markets. We reconstruct their measure of industry-specific financial dependence for our analysis, and show that our measure of sectoral scale (workers per establishment) is closely related to external dependence. For instance, the tradable sector not only has a larger scale than the non-tradable sector, but also has a higher external dependence.[4] Note that we study the impact of financial frictions on the level of sectoral productivity rather than their impact on the growth rate of sectoral output. Erosa and Hidalgo Cabrillana (2008) is a theoretical paper showing how financial frictions can have differential effects on the productivity of manufacturing industries with different fixed-cost requirements. Our paper differs from these two papers in three ways. First, our analysis explicitly combines data and theory to quantify the effect of financial development on sectoral productivity. Second, we introduce scale as an empirical measure related to fixed costs and financing needs. Finally, we broaden the analysis to encompass both tradable (large-scale) and non-tradable (small-scale) sectors.

A literature in international trade provides theoretical analyses and empirical evidence for how financial frictions may affect the comparative advantage of countries. Theoretical contributions include Kletzer and Bardhan (1987), Matsuyama (2005), Wynne (2005) and Manova (2008b). Beck (2002) and Manova (2008a), among others, show empirically that financially-underdeveloped countries tend to specialize in sectors that are not financially dependent. We complement this literature by developing a quantitatively-oriented dynamic model that can potentially be used to assess the role of financial development on the pattern of trade.

Finally, we add to the broader literature on the role of micro-level distortions (Hsieh and Klenow, 2007a; Guner et al., 2008; Restuccia and Rogerson, 2008). Our results complement the empirical findings of Hsieh and Klenow (2007a) in particular. They find a factor-of-two difference in manufacturing TFP due to the misallocation of capital and labor. We explicitly model one source of such misallocation (financial frictions), and include the non-tradable sector in our analysis. Furthermore, we explore how distortions affect the entry and exit decisions of establishments.

The next section documents the key facts that motivate our analysis. Section 3 develops the model, and characterizes the perfect-credit benchmark. Section 4 presents the quantitative experiments and evaluates the model implications on sectoral scales using detailed

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[4]A strand of the empirical literature has examined the independent effects of scale and financing needs (Beck et al., 2008).

sectoral data from the US, Mexico and other OECD countries. Section 5 concludes.

2   Facts

This section documents the key empirical facts motivating our study. First, we revisit a well-known case of sectoral productivity differences across countries, the Balassa-Samuelson effect—the positive relationship between relative productivity in tradable goods and output per worker. We also show that a similar relationship holds between relative productivity and financial development. Second, we point out that there are large differences in scale of operation among broadly-defined sectors, e.g. tradable vs. non-tradable sectors. We emphasize this sectoral difference in scale, rather than tradability of goods per se, in interpreting the relative productivity of sectors. We further show that this relationship between relative productivity and scales of operation holds at a more disaggregated level as well: Goods that are produced with large-scale technologies in developed countries tend to be relatively more expensive in developing economies, reflecting their low relative productivity in these industries.

Relative Productivity and Development   The first example of cross-country differences in relative productivity of sectors was documented by Balassa (1964) and Samuelson (1964). The Balassa-Samuelson fact is that in poor countries the prices of tradable goods are high relative to those of non-tradable goods. Figure 1 confirms this fact using the 1996 ICP benchmark by plotting the relative price of tradables against output per worker from the Penn World Tables 6.2.[5] Here the relative price is compiled by creating Geary-Khamis aggregated prices for the tradable and the non-tradable sectors using 27 disaggregated product categories.[6] The log relative prices (tradables to non-tradables) have a strong negative relationship with the log of output per worker across countries. The slope coefficient of -0.37 is highly significant with a standard error of 0.04, and the regression has an R^2 of 0.42.

   This relationship can be interpreted as reflecting a lower total factor productivity of 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, relative prices

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[5]ICP stands for the International Comparison Programme of the United Nations. 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 Beck et al. (2000) constructed data on financial development. The results using all 115 countries are virtually identical.

[6]The tradables category consists of clothing, nine 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 category consists 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.
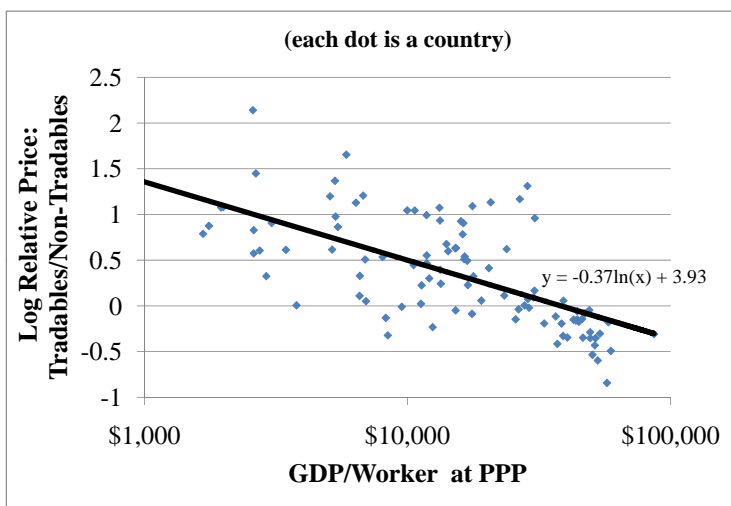
(each dot is a country)

Log Relative Price: Tradables/Non-Tradables

$y = -0.37\ln(x) + 3.93$

GDP/Worker at PPP

Fig. 1: Relative price of tradables to non-tradables against GDP per worker.

equal the inverse of relative TFP. See, for example, Hsieh and Klenow (2007b). 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 much across sectors, and if anything, the non-tradable sector tends to be more intensive in human and physical capital.[7] In this paper, we explore the root of this relationship between the relative TFP of sectors and output per worker.

Relative Productivity and Financial Development   A common measure of a country's level of financial development is its ratio of external financing (the sum of private credit, private bond market capitalization, and stock market capitalization) to GDP (La Porta et al., 1998; Rajan and Zingales, 1998; Beck et al., 2000). The relationship between relative prices and external financing to GDP ratios is quite similar to the one between relative prices and GDP in Figure 1. The estimated elasticity of 0.32 is slightly lower, but the R^2 of 0.50 is slightly higher.

The strength of the relationship suggests that financial development is potentially closely related to the Balassa-Samuelson fact. In the model we develop, it is financial development that is the causal force behind the cross-country differences in both relative prices and output per worker.

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[7]See Valentinyi and Herrendorf (2008) for physical capital intensity, and Buera and Kaboski (2008) for human capital intensity.

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Scale Differences across Sectors   Another key empirical fact that motivates our study is the clear difference in the scale of production units across broadly-defined sectors. Our interpretation is that this sectoral scale difference reflects differences in production technologies across these sectors. We will argue that these technological differences interact with financial development, so that financial development affects large-scale and small-scale sectors differently.

Here we use two measures for scale of operation: workers per establishment and workers per enterprise. Establishments are locations of business, so that a single enterprise, Walmart, for example, may have multiple establishments. Table 1 presents measures of average scale across broadly-defined final goods sectors of the US and other OECD countries, and compares these scale measures with other sector-level technological characteristics like financial dependence and factor intensities.[8]

	Workers per Establishment	Workers per Enterprise	External Dependence Ratio	Capital Share
	U.S.	OECD Averages	U.S.	U.S.
Manufactured Consumption (M)	42	20	0.27	0.33
Services (S)	16	8	0.09	0.27
Equipment Investment (E)	81	35	0.14	0.29
Construction (C)	10	7	0.08	0.17
Tradables (M+E)	48	28	0.21	0.31
Non-tradables (S+C)	15	8	0.08	0.26

Table 1: The averages are worker-weighted averages across four-digit industries in the OECD SSIS data, and across eight-digit industries in the US census data. The OECD data cover nine countries, and are complete at the enterprise level: Czech Republic, France, Germany, Hungary, Slovakia, Poland, Portugal, the UK and the US. The external dependence ratio is calculated using the formula of Rajan and Zingales (1998). They measure the ratio of the difference between capital expenditures and cash flow to capital expenditures. In order to negate the influence of outliers, we follow their methodology of using the total capital expenditures and total cash flow over the sample period (1993–2003) to compute firm-specific numbers, and then report the median value within an industry as the industry-specific value. Capital shares are from Valentinyi and Herrendorf (2008). They correspond to the capital share of gross output in each of these broadly-defined sectors, and are calculated using input-output data from the Industry Accounts of the Bureau of Economic Analysis.

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[8]These sectors are constructed to be consistent with the final goods categories 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 constitute tradables. Services include accommodation/food services, arts/entertainment, communication, education, FIRE, health, retail, sewage, transportation, and wholesale.

The first column is based on data from the 2002 US Economic Census, which uses an establishment basis and the NAICS eight-digit classification. The second column is based on the OECD Structural Statistics for Industry and Services (SSIS) database for 2002. These data follow the common ISIC 3.2 four-digit classification, enabling comparison across OECD countries. Enterprise-level data permit comparison over the largest set of countries: Czech Republic, France, Germany, Hungary, Slovakia, Poland, Portugal, the UK and the US.[9]

Whether establishments or enterprises are the unit of measurement, the average scale varies considerably across these broadly-defined sectors. The top panel shows the average scale in manufactured consumption, services, equipment investment, and construction. Manufactured consumption and equipment investment establishments tend to operate at a large scale, while services and construction establishments have smaller scales. This distinction is precisely the tradables vs. non-tradables dichotomy in the bottom panel. The tradable sector has a substantially larger scale than the non-tradable sector.[10] In the US census data for workers per establishment, the typical tradable establishment is over 3.2 times as large as its non-tradable counterpart (48 vs. 15). The relative scale of tradables to non-tradables is even larger with enterprises as the unit of observation. For the OECD average, the ratio is 3.5 (28 vs. 8). Establishments are our preferred unit of analysis because we think they embody production technologies, but some technologies (e.g., the distribution system of Walmart) may be at the firm level. Data availability dictates which measure we use in certain cases.

In our model, financial frictions have differential impact on sectors with different scales because our notion of scale (workers per establishment or enterprise) coincides with financing needs. Support for this interpretation can be obtained by comparing other measures of financing needs across sectors. The third column reports the measures of external dependence (Rajan and Zingales, 1998) that we construct using the US Compustat data for 1993–2003.[11] In the Compustat data, firms in the tradable sector are substantially more financially-dependent than those in the non-tradable sector, with a median of 0.21 vs. 0.08.[12]

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[9]There are also subtle differences in the definition of workers between the two samples. In particular, the SSIS data measure "number of persons engaged," which can include some temporary or contract workers. The census data record "number of employees," which excludes proprietors. For some countries, SSIS data have both measures, and the two mirror each other closely.

[10]We lack comparable scale data for agriculture, another component of tradables. In advanced economies, land/capital investment per farm is substantial, but workers per farm may not be large.

[11]Rajan and Zingales measure the ratio of the difference between capital expenditures (Compustat #128) and cash flow (Compustat #110, or the sum of #123, 125, 126, 106, 213, and 217, for format code 7) to capital expenditures. In order to negate the influence of outliers in noisy firm-level data, they take the total capital expenditures and total cash flow over the sample period to compute firm-specific numbers, and then pick the median value within an industry as the industry-specific value. Note that Rajan and Zingales only included the manufacturing sector in their study.

[12]Alternative measures of firms' financing needs give a similar picture. For example, we have constructed a measure of setup costs. In particular, for each firm in Compustat, we have located the first period with

Furthermore, differences in external dependence line up fairly closely with differences in scale at a more disaggregated level (top panel of Table 1). While external dependence may be a more direct measure of financing needs or investment requirements, we decide to focus on scale (employment), a measure that is available for all firms and sectors in the economy, as opposed to just the publicly-traded firms in Compustat.[13]

Finally, the fourth column reports the sectoral differences in factor intensities. These numbers are from Valentinyi and Herrendorf (2008), and correspond to the capital share of gross output in each of these broadly-defined sectors. Unlike differences in scale and external dependence, the variation in factor intensity is relatively small and does not show a consistent pattern across sectors. The difference between services and equipment investment is negligible, and only for construction we observe a significantly lower capital intensity. Chari et al. (1997) also find little difference in factor shares between investment and consumption goods sectors, with, if anything, investment goods producers being more labor-intensive. The relatively small variation in factor intensity across sectors leads us to follow the recent literature (Chari et al., 1997; Hsieh and Klenow, 2007b) and build a model that abstracts from these differences. Our focus is instead on the large observed differences in scale across sectors.

Relative Prices and Scale   We have seen that the relative price of tradables is high in poor countries, and that tradable establishments operate at larger scales than non-tradable establishments. A natural question to ask is whether relative prices and the scale of production technologies are related at a more disaggregated level as well. We examine this issue using disaggregated ICP price data from its 1996 benchmark. The scale of operation in an industry is constructed by averaging across eight countries for which comparable data are available.[14] We then map ICP categories into closely related groups of industries and calculate the average scale for these industry groups.[15] Finally, we run a cross-country regression

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[13]positive excess investment, and calculated the average excess investment over following consecutive periods with positive excess investment. For the firms in the tradable sector, the ratio of this measure over annual sales has a median of 0.65, while for those in the non-tradable sector, a median of 0.12.

[13]See Davis et al. (2006) for an example where conclusions drawn from the universe of firms and from the set of publicly-traded firms can be very different.

[14]OECD SSIS data—which cover all industries, not just manufacturing—are available for eight countries (Czech Republic, France, Germany, Hungary, Poland, Portugal, Slovakia, and the UK), but only at the enterprise level. We therefore use number of persons engaged per enterprise as our measure of scale. For any given industry at a disaggregated level, there is a strong correlation in scale across countries. Still, we average across many countries to smooth out idiosyncratic variations that may arise from local market structures, government regulations, and so on.

[15]A 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 the lack of comparable data on agriculture, only the scale of food manufacturing establishments could be used. It is at least comforting that none of the food categories appears to be outliers.

of 2,794 disaggregated ICP price data from 112 countries on log output per worker, log industry scale, and their interaction. The estimation result is (with t-statistics in parentheses):

$$\log p_{i,j} = \underset{(-13.0)}{-7.25} + \underset{(12.2)}{0.71} \log y_i + \underset{(6.5)}{0.97} \log \ \bar{l}_j - \underset{(-6.2)}{0.10} \log y_i \log \bar{l}_j, \quad R^2 = 0.21,$$

where $p_{i,j}$ is the 1996 price of industry j goods in country i, y_i is the output per worker of country i in 1996 international prices, $\bar{l}_j$ is the average number of workers engaged per enterprise for industry j. The negative coefficient on the interaction term indicates that prices of the output of industries with larger scales are relatively higher in low income countries. Given the log difference between tradables and non-tradables scales in Table 1— 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 1.

The general magnitude and significance of this result at the five-percent level are robust. Alternative specifications used country-specific fixed effects instead of controlling for $\log y_i$, and/or category-specific fixed effects instead of controlling for $\log \bar{l}_j$. Yet another specification substituted countries' ratios of external finance to GDP for $\log y_i$. The significance of the result at the five-percent level is also robust to clustering standard errors by country or by ICP category.
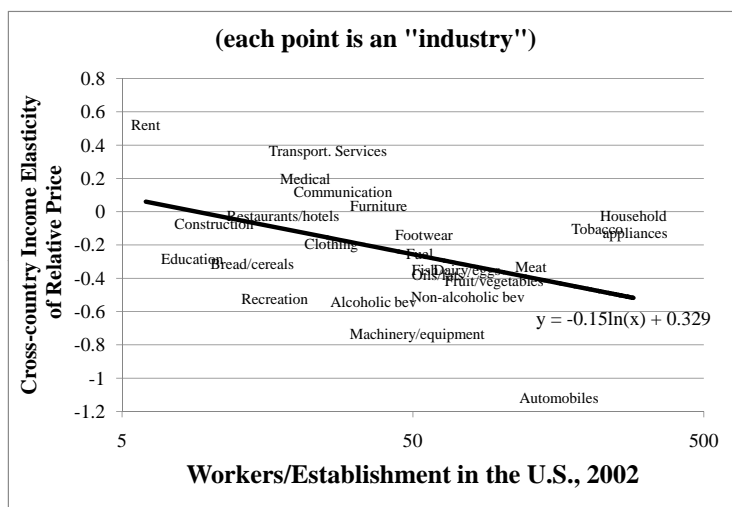

Fig. 2: Industry-specific elasticity of relative price with respect to income across countries (vertical axis) plotted against industry-specific scale (horizontal axis).

We visually represent this result in Figure 2. First, for each sector j, we run a cross-country regression of the log of sectoral price ($p_{i,j}$ relative to country PPP) on log output

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per worker ($\log y_i$). These sector-specific regression coefficients (income elasticities of relative prices, vertical axis) are plotted against sectoral scales (horizontal axis) in Figure 2. These coefficients have a downward slope of -0.15; that is, the relative price of goods produced in larger-scale industries will increase more when moving from rich to poor countries.

We conclude that, even at a more disaggregate level, poor countries are particularly unproductive in industries with larger scales. This is further evidence supporting our emphasis on sectoral scale differences.

3 Model

We model an economy with two sectors, S (small-scale, non-tradable sector) and L (large-scale, tradable consumption and investment goods sector). In each sector, there are two occupations: worker and entrepreneur. The economy is open and takes the price of goods produced with large-scale technologies (tradables) as given; in the stationary equilibria that we consider, with only one tradable good, openness will simply fix the price of the tradable output, which is our numeraire.

There are a measure N of infinitely-lived individuals, who are heterogeneous in their wealth and the quality of their entrepreneurial ideas, $z = (z_S, z_L)$. Individuals' wealth is determined endogenously by forward-looking behavior. The vector of entrepreneurial ideas is drawn from a distribution $\mu(z)$. Entrepreneurial ideas "die" with a constant hazard rate of $1 - \gamma$, and a new vector of ideas is independently drawn from $\mu(z)$. The parameter γ therefore controls the persistence of the entrepreneurial idea process.[16]

In each period, individuals choose their occupation: whether to work for a wage or to operate a business in sector S or L. Their occupational choices are based on their comparative advantage as an entrepreneur (z) and their access to capital. Access to capital is limited by agents' wealth because capital rental contracts may not be perfectly enforceable in our model, giving rise to an endogenous collateral constraint.

One entrepreneur can operate only one production unit (establishment) in a given period. Entrepreneurial ideas are inalienable, and there is no market for managers or entrepreneurial talent. The way we model an establishment draws upon the span of control of Lucas (1978) and per-period fixed costs as in Rossi-Hansberg and Wright (2007).

Preferences Individual preferences are described by the following expected utility function over sequences of consumption $c_t = (c_{S,t}, c_{L,t})$:

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[16]This shock can be interpreted as changes in market conditions that affect the profitability of individual skills. Alternatively, in a life-cycle interpretation of the model, the current generation dies and is replaced with an offspring that does not share the same talent. In either of these interpretations, we model productivity to follow a very persistent process in between the arrival of idea shocks.

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

where $u(c_t) = \left(c_{S,t}^{1-1/\varepsilon} + c_{L,t}^{1-1/\varepsilon}\right)^{\frac{1-\sigma}{1-1/\varepsilon}} / (1-\sigma)$, β is the discount factor, σ the coefficient of risk-aversion (and the reciprocal of the elasticity of intertemporal substitution), and ε the intratemporal elasticity of substitution between goods produced with small and large-scale technologies. The expectation is over the realizations of entrepreneurial ideas (z), which depend on stochastic death of ideas $(1-\gamma)$ and on draws from $\mu(z)$.

Technology At the beginning of each period, an individual with vector of entrepreneurial ideas z and wealth a chooses whether to work for a wage w or operate a business in either sector $j = S, L$. To operate a business in a sector, individuals must pay a sector-specific per-period fixed cost of κ_j, in units of the sector's output. The crucial assumption is that the fixed cost to run an establishment in the large-scale sector is higher than that in the small-scale sector, $\kappa_L > \kappa_S$. This will generate the scale difference between the two sectors that we observe in the data. In our quantitative analysis, we will set κ_S to zero.

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

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

where α and θ are the elasticities of output with respect to capital and labor, and $\alpha + \theta < 1$, implying diminishing returns to scale in variable factors at the establishment level. Note that the factor elasticities are assumed to be the same in both sectors, which is consistent with the empirical findings in the literature (Chari et al., 1997; Valentinyi and Herrendorf, 2008).

Given factor prices w and R (rental rate of capital), the profit of an entrepreneur is:

$$\pi_j(k,l;R,w,p) = p_j z_j k^\alpha l^\theta - Rk - wl - (1+r)p_j \kappa_j,$$

where r is the interest rate, and p_j is the price of sector j goods. Sector S produces non-tradable consumption goods, and the output from sector L is investment goods and tradable consumption goods. We normalize p_L to one. For later use, we define the optimal level of capital and labor inputs when production is not subject to financial constraints:

$$(k_j^u(z_j), l_j^u(z_j)) = \arg\max_{k,l}\left\{p_j z_j k^\alpha l^\theta - Rk - wl\right\}.$$

The key feature of this technology is that the fixed costs introduce non-convexity. For any strictly positive fixed cost κ_j, the technology is feasible only if operated above the minimum scale; i.e., $z_j k^\alpha l^\theta \geq (1+r)\kappa_j$.[17]

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[17]The model can be extended to allow for a choice of technologies within each sector: a technology with

Credit and Rental Markets Individuals have access to competitive financial intermediaries, who (i) receive deposits, (ii) rent capital k at rate R, and (iii) lend to entrepreneurs their fixed cost $p_j \kappa_j$. In the benchmark model, we restrict the analysis to the case where both borrowing and capital rental are within a period—that is, $a \geq 0$. The zero-profit condition implies $R = r + \delta$, where r is the deposit and lending rate and δ is the depreciation rate.

Borrowing and capital rental by entrepreneurs are limited by imperfect enforceability of contracts. In particular, we assume that, after production has taken place, entrepreneurs have the option to renege on the contracts. In such cases, the entrepreneurs can keep a fraction $(1 - \phi)$ of the undepreciated capital and the revenue net of labor payments, $(1 - \phi) [p_j z_j f(k, l) - wl + (1 - \delta) k]$. The only punishment is the garnishment of their financial assets deposited with the financial intermediary, a. In the following period, this entrepreneur in default will regain access to financial markets, and will not be treated any differently despite the history of default.

Note that ϕ indexes the strength of an economy's legal institutions enforcing contractual obligations. This one-dimensional parameter captures the extent of frictions in the financial market due to imperfect enforcement of credit and rental contracts. This specification allows for a flexible modeling of limited commitment that spans economies with no credit ($\phi = 0$) and with perfect credit markets ($\phi = 1$).

We consider equilibria where the borrowing and capital rental contracts are incentive-compatible and are hence fulfilled. In particular, we study equilibria where the rental of capital is quantity-restricted by an upper bound $\bar{k}^j(a, z_j; \phi)$, which is a sector-specific function of the individual state (a, z_j). We choose the rental limits $\bar{k}^j(a, z_j; \phi)$ to be the largest limits that are consistent with entrepreneurs choosing to abide by their rental and borrowing contracts. Without loss of generality, we assume $\bar{k}^j(a, z_j; \phi) \leq k_j^u(z)$, where k_j^u is the profit-maximizing capital inputs in an unconstrained (static) problem in sector j.

The following proposition provides a simple characterization of the set of enforceable contracts and the rental limits $\bar{k}^j(a, z_j; \phi)$, for $j = S, L$.

Proposition 1 *Capital rental k in sector j by an entrepreneur with wealth a and talent z_j is enforceable if and only if*

$$\max_l \{p_j z_j f(k, l) - wl\} - Rk - (1 + r) p_j \kappa_j + (1 + r) a$$
$$\geq (1 - \phi) \left[\max_l \{p_j z_j f(k, l) - wl\} + (1 - \delta) k \right]. \tag{2}$$

---

a small fixed cost and low productivity, $A_{1,j} z_j k^\alpha l^\theta - \kappa_1$, and a technology with a large fixed cost and high productivity, $A_{2,j} z_j k^\alpha l^\theta - \kappa_2$, with $A_{2,j} > A_{1,j}$ for $j = S, L$ and $\kappa_2 > \kappa_1$. Note that in this extension fixed costs are technology specific and not sector specific. One can think of our current setup as a case where the productivity gains associated with the κ_2-technology is substantially larger for the large-scale sector; i.e., $A_{2,L} \gg A_{2,S}$.

Therefore, the upper bound on capital rental that is consistent with entrepreneurs choosing to abide by their rental and borrowing contracts can be represented with a function $\bar{k}^j(a, z_j; \phi)$, which is increasing in a, z_j and ϕ.

Condition (2) states that the economic resources of an entrepreneur repaying her rental and credit obligations (left-hand side) have to be at least as large as those of a defaulting entrepreneur (right-hand side). This condition is sufficient to characterize enforceable allocations because we assume that defaulting entrepreneurs regain access to financial markets in the following period.

This proposition also provides a convenient way to operationalize the enforceability constraint into a simple rental limit $\bar{k}^j(a, z_j; \phi)$.[18] As long as the unconstrained level of capital rental is not enforceable, the rental limit $\bar{k}^j(a, z_j; \phi)$ is implicitly defined as the larger root of the equation given by the equality in condition (2). Rental limits increase with the wealth of entrepreneurs, because the punishment for defaulting (loss of collateral) gets larger. Similarly, rental limits increase with the talent of an entrepreneur because defaulting entrepreneurs keep only a fraction $1 - \phi$ of the output. In the rest of the paper, we restrict individuals' capital inputs to be less than or equal to the rental limit $\bar{k}^j(a, z_j; \phi)$.

While the enforceability of contracts as measured by ϕ is not sector-specific, the equilibrium enforceable rental contracts, as captured by the rental limits $\bar{k}^j(a, z_j; \phi)$, do vary across sectors because of the differences in technology and in output prices across sectors.

Recursive Representation of Individuals' Problem Here we discuss the problem solved by individuals. In particular, we define the value for an individual before the occupational choice, $v(a, z)$, as well as the value of being a worker, $v^w(a, z)$, and being an entrepreneur in sector j, $v^j(a, z)$, for $j = S, L$.

Individuals maximize (1) by choosing sequences of consumption, financial wealth, occupations (including the sector), and capital/labor inputs if they choose to be entrepreneurs, subject to a sequence of period budget constraints and rental limits.

At the beginning of a period, an individual's state is summarized by her wealth, a, and the vector of abilities, z. The individual then chooses between being a worker or being an entrepreneur in sector S or L for the period. The value for an individual at this stage, $v(a, z)$, is the maximum over the value of being a worker, $v^w(a, z)$, and the value of being an entrepreneur in sector j, $v^j(a, z)$, for $j = S, L$:

$$v(a, z) = \max\left\{v^w(a, z), v^S(a, z), v^L(a, z)\right\}. \tag{3}$$

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[18]In general, the set of enforceable capital rentals dictated by (2) does not exactly correspond to $k \leq \bar{k}^j(a, z_j; \phi)$. For example, an entrepreneur who is only offered a very low (and unprofitable) level of capital will default if $p_j \kappa_j$ is large enough. Notwithstanding this, the solution to the individual's problem subject to (2) coincides with the solution to the individual's problem subject to the simpler rental limit $k \leq \bar{k}^j(a, z_j; \phi)$.

Note that the value of being a worker, $v^w(a, z)$, depends on her assets a and on her entrepreneurial ideas z, which may be implemented at a later date. Similarly, the value of being an entrepreneur in sector j, $v^j(a, z)$, depends on the entire vector of entrepreneurial ideas, as she may switch sectors at a later date.

As a worker, an individual chooses consumption bundle $c = (c_S, c_L)$ and the next period's assets a' to maximize her continuation value subject to the period budget constraint:

$$v^w(a, z) = \max_{c, a' \geq 0} u(c) + \beta [\gamma v(a', z) + (1 - \gamma) \mathbb{E}_{z'}[v(a', z')]] \tag{4}$$

$$\text{s.t. } pc + a' \leq w + (1 + r)a,$$

where w is her labor income, and p denotes the vector of goods prices. The continuation value is a function of the end-of-period state (a', z'), where $z' = z$ with probability γ and $z' \sim \mu(z')$ with probability $1 - \gamma$. In the subsequent period, she will face an occupational choice again, and the function $v(a, z)$ appears in the continuation value.

Alternatively, individuals can choose to become an entrepreneur in sector j. The value function of being an entrepreneur in sector j is as follows.

$$v^j(a, z) = \max_{c, a', k, l \geq 0} u(c) + \beta [\gamma v(a', z) + (1 - \gamma) \mathbb{E}_{z'}[v(a', z')]] \tag{5}$$

$$\text{s.t. } pc + a' \leq p_j z_j f(k, l) - Rk - wl - (1 + r)p_j \kappa_j + (1 + r)a$$

$$k \leq \bar{k}^j(a, z_j; \phi)$$

Note that an entrepreneur's income is given by period profit $p_j f(z_j, k, l) - Rk - wl$ net of fixed costs $(1 + r)p_j \kappa_j$ plus the return to her initial wealth, and that her choices of capital inputs are constrained by the rental limit $\bar{k}^j(a, z_j; \phi)$.

Stationary Competitive Equilibrium A stationary competitive equilibrium is composed of: an invariant distribution of wealth and entrepreneurial ideas $G(a, z)$; occupation choice function $o(a, z)$, and policy functions $c(a, z)$, $a'(a, z)$, $l(a, z)$, and $k(a, z)$; rental limits $\bar{k}^j(a, z_j; \phi)$, $j = S, L$; and prices w, R, r, and p such that:

1. Given $\bar{k}^j(a, z_j; \phi)$, w, R, r and p, the individual policy functions $o(a, z)$, $c(a, z)$, $a'(a, z)$, $l(a, z)$, $k(a, z)$ solve (3), (4) and (5);

2. Financial intermediaries make zero profit, i.e., $R = r + \delta$;

3. Rental limits $\bar{k}^j(a, z_j; \phi)$ are the most generous limits satisfying condition (2), and $\bar{k}^j(a, z_j; \phi) \leq k_j^u(z_j)$;

4. Credit, labor, non-tradable consumption goods, and tradable consumption/investment goods markets clear;

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

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

Perfect-Credit Benchmark To clarify the basic mechanics of the model, we analyze the perfect credit benchmark, $\phi = 1$. This is an economy with unconstrained within-period borrowing and capital rental for production (i.e., $\bar{k}^j(a, z_j, \phi) = k_j^u(z)$ for all a) but without between-periods borrowing or consumption insurance. We present two results characterizing the production side of the perfect-credit economy under the assumption that entrepreneurial talents for the two sectors follow mutually independent Pareto distributions with the same tail parameter η, $(z_L, z_S) \sim \eta^2 (z_L z_S)^{-(\eta+1)}$. This assumption permits approximate closed-form expressions for net sectoral production functions (i.e., sectoral output net of fixed costs), factor shares, and the establishment size distribution. The assumption of mutually-independent Pareto distributions also implies that the establishment size distribution within each sector exhibits a thick right tail, a salient feature of the data.[19] These characterizations will help us pin down the technological parameters of the model using data on establishment size distributions across and within sectors.[20]

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

Proposition 2 *Assume that entrepreneurial talents for the two sectors follow mutually-independent Pareto distributions with the same tail parameter η, $(z_S, z_L) \sim \eta^2 (z_S z_L)^{-(\eta+1)}$, and that active entrepreneurs are a small fraction of the population. Then the output of a sector net of fixed costs equals:*

$$Y_j(K_j, L_j; N) = A_j N^{\frac{1/\eta}{\alpha+\theta+1/\eta}} K_j^{\frac{\alpha}{\alpha+\theta+1/\eta}} L_j^{\frac{\theta}{\alpha+\theta+1/\eta}},$$

where

$$A_j = \frac{\left[\frac{(1-\alpha-\theta)}{\eta(1-\alpha-\theta)-1}\eta\right]^{\frac{1}{1+\eta(\alpha+\theta)}} \left[1 - \frac{p_j \kappa_j}{p_j \kappa_j + w}\left(1 - \alpha - \theta - \frac{1}{\eta}\right)\right]}{\left[\frac{p_j \kappa_j}{w} + 1\right]^{\frac{\eta(1-\alpha-\theta)-1}{1+\eta(\alpha+\theta)}}}.$$

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[19]If instead entrepreneurial ideas were to be correlated across sectors, the model would deliver a thin tail for the distribution of establishments in the sector with low fixed costs, which is inconsistent with data.

[20]We solve the perfect-credit benchmark in two steps. First, given an aggregate supply of capital and the intratemporal (homothetic) consumption decisions, 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 saving decisions of individuals facing idiosyncratic shocks to entrepreneurial ideas. By aggregating over individuals, we obtain the aggregate supply of capital. A stationary equilibrium with perfect credit markets is a nested fixed point of these two problems.

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 factor shares, because entrepreneurs earn rents. In particular, payments to capital as a share of income equals:

$$s_{K,j} = \frac{RK_j}{Y_j(K_j, L_j; N)} = \frac{\alpha}{1 - \frac{p_j\kappa_j}{p_j\kappa_j+w}\left(1 - \alpha - \theta - \frac{1}{\eta}\right)}.$$

For realistic parameterizations of the model, $1 - \alpha - \theta - \frac{1}{\eta}$ is close to zero, and hence factor shares in the two sectors are approximately equal.

Our second result pertains to the establishment size distribution in the perfect-credit benchmark. In particular, we show that the establishment size in each sector follows a Pareto distribution with tail coefficient $\eta(1 - \alpha - \theta)$, and that the overall establishment size distribution in the economy is a mixture of Pareto distributions. We also show that there is a direct mapping between the ratio of fixed costs to wage ($p_j\kappa_j/w$) and the ratio between the average establishment sizes ($\bar{l}_j$) of the two sectors.

Proposition 3 *Assume that entrepreneurial talents for the two sectors follow mutually-independent Pareto distributions with the same tail parameter η, $(z_S, z_L) \sim \eta^2 (z_S z_L)^{-(\eta+1)}$, and that active entrepreneurs are a small fraction of the population. Then the establishment size distribution in each sector follows the power law:*

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

where $l(\hat{z}_j)$ is the employment in the marginal establishment. Furthermore, the establishment size distribution in the aggregate economy is given by a mixture of Pareto distributions:

$$\Pr\left[\tilde{l} > l\right] = n_S \left(\frac{l(\hat{z}_S)}{l}\right)^{\eta(1-\alpha-\theta)} + n_L \left(\frac{l(\hat{z}_L)}{\max\{l, l(\hat{z}_L)\}}\right)^{\eta(1-\alpha-\theta)}, \quad l \geq l(\hat{z}_S),$$

where n_S and n_L are respectively the fraction of small and large-scale establishments in the economy, with $n_S + n_L = 1$. Also, the ratio of the average establishment size between the two sectors is:

$$\bar{l}_j/\bar{l}_{j'} = (p_j\kappa_j + w)/(p_{j'}\kappa_{j'} + w).$$

This last result suggests a simple way of identifying the relative magnitude of fixed costs across sectors from the relative scale of sectors. In our model, the large scale of a sector arises from the large fixed costs at the establishment level. In addition, the tail of the establishment size distribution identifies the parameter governing the distribution of entrepreneurial talents. In the next section, these observations will enable us to calibrate the model in a transparent manner. We then study the impact of financial frictions on aggregate and sectoral productivity, and on the establishment size distribution.

4 Quantitative Analysis

In this section, we first calibrate the perfect-credit benchmark of our model economy to the US economy. We then conduct experiments to assess the effect of financial frictions. In particular, we vary ϕ, the parameter governing the degree of financial frictions, to obtain variations in external finance to GDP ratios that are comparable to the range observed in a cross-section of countries. We evaluate our model predictions for aggregate and sectoral TFP, relative prices, and output per worker. Finally, we explore our model implications for the relative scale of establishments across sectors using data from developing and developed countries.

In our quantitative analysis we hold fixed all technological parameters across countries, and vary only the parameter governing financial frictions (ϕ). In particular, we assume (rather counterfactually) that countries are endowed with the same entrepreneurial talent distribution. We maintain this assumption because our goal is to isolate and quantify the direct impact of financial frictions. One of our main results is that, starting with the same potential pool of entrepreneurs, financial frictions distort the selection into active entrepreneurship. The productivity distribution of entrepreneurs in operation therefore differs across countries, with financial frictions lowering the mean and raising the variance of this distribution. The effect on the mean conforms to the conventional wisdom on aggregate productivity differences across countries. The increase in variance is consistent with recent empirical work of Hsieh and Klenow (2007a), who find that less developed countries' establishment-level productivity (TFPQ in their terminology) dispersion is at least as large as that of the US. It would be straightforward to incorporate cross-country differences in the average productivity of potential entrepreneurs and workers by considering human capital and exogenous TFP differences. It is less obvious how one would model exogenous cross-country differences in higher moments of the entrepreneurial talent distribution.

4.1 Calibration

We calibrate preference and technology parameters so that the perfect-credit economy matches key aspects of the US, a relatively undistorted economy. In particular, our target moments include standard macroeconomic aggregates, features of the establishment size distribution within and across sectors, establishment dynamics, and the concentration of income in the population.

In our quantitative analysis we identify our small-scale sector with the non-tradable sector, and our large-scale sector with those producing investment goods and tradable goods. That is, we focus on the best-known case of sectoral productivity differences across countries,

the Balassa-Samuelson effect (Section 2).[21]

We need to specify values for ten parameters: four technological parameters, α, θ, κ_S, and κ_L, and the depreciation rate δ; two parameters describing the process for entrepreneurial talents, 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 set to standard values in the literature. We let $\sigma = 1.5$ and $\varepsilon = 1.0$.[22] The one-year depreciation rate is set at $\delta = 0.058$, and we choose $\frac{\alpha}{\alpha+\theta}$ to match the aggregate capital income share of 0.33.

We are thus left with the six parameters that are more specific to our study: $\alpha + \theta$, κ_S, κ_L, η, γ, and β.[23] We calibrate them to match six relevant moments in the US data as shown in the first column of Table 2: the average size of establishments in non-tradables (15) and in investment goods/tradables (48); the employment share of the top decile of establishments (0.63); the share of income generated by the top five percentile of earners (0.30); the annual exit rate of establishments (0.10); and the annual real interest rate (0.05).

Target Moments	US Data	Model	Parameter
Top 10% employment share	0.63	0.63	$\eta = 5.30$
Top 5% income share	0.30	0.29	$\alpha + \theta = 0.80$
Avg. scale in non-tradable sector	15	15	$\kappa_S = 0.00$
Avg. scale in tradable/investment goods sectors	48	46	$\kappa_L = 2.00$
Exit rate	0.10	0.10	$\gamma = 0.89$
Interest rate	0.05	0.05	$\beta = 0.92$

Table 2: Calibration

The identification of these six parameters follows the basic logic given in our discussion of the perfect-credit benchmark. We calibrate the fixed costs, $\kappa_S = 0.0$ and $\kappa_L = 2.0$, to match the average establishment size in the small-scale (non-tradables) and the large-scale (investment goods/tradables) sectors (15 and 48, respectively). The per-period fixed cost in the large-scale sector, $\kappa_L = 2.0$, is tantamount to about three times the equilibrium wage in the perfect-credit benchmark. Given the returns to scale, $\alpha + \theta$, we choose the tail parameter

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[21]One alternative is to classify industries (at a more disaggregated level) into small vs. large scale sectors, on the basis of some industry-specific scale measures. This way, we would maximize the scale differences between these two broadly-defined sectors, and hence their differences in fixed costs. We choose the non-tradable vs. tradable mapping, to be on the conservative side in model specification, and to draw upon the existing body of work on this topic.

[22]The intratemporal elasticity of 1.0 is within the range of the estimates in the literature. Ostry and Reinhart (1991) estimate it to be 1.24 for a group of developing countries, and Mendoza (1995) reports an elasticity of 0.74 for a group of industrialized countries.

[23]As is common in heterogeneous-agent models with financial frictions, the discount rate must be jointly calibrated with the parameters governing the stochastic income process.

of the entrepreneurial talent distribution, $\eta = 5.3$, to match the employment share of the largest ten percentile 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 fraction of output going to the entrepreneurial input. The parameter $\gamma = 0.89$ leads to an annual establishment exit rate of ten per cent in the model. This is consistent with the job destruction rate in the US reported by Davis et al. (1996). Finally, the model requires a discount factor of $\beta = 0.92$ to match the annual interest rate of five per cent.
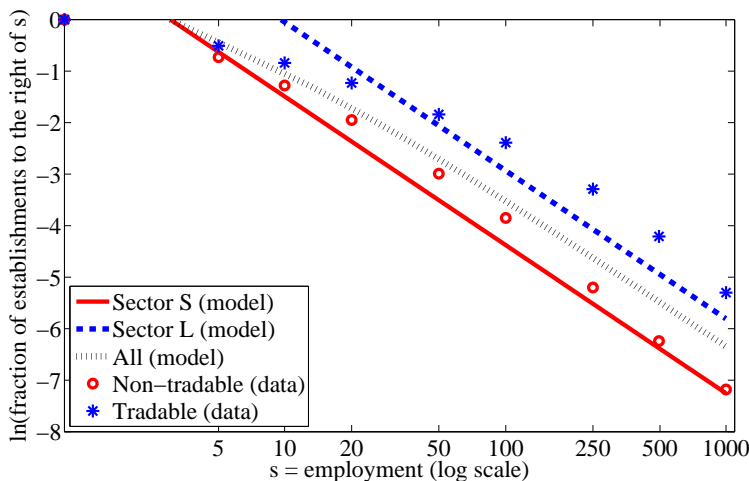

Fig. 3: Establishment size distributions in the data and in the model. The horizontal axis is the number of employees (s) in log scale. For each s, one computes the fraction of establishments whose number of employees is greater than or equal to s, and takes log of this fraction (vertical axis). As we assume a Pareto distribution for entrepreneurial talent in each sector, the perfect-credit benchmark yields straight lines for the small-scale sector (solid line) and the large-scale sector (dashed line). One can construct such a line using all the establishments in our perfect-credit benchmark (inclusive of both sectors), which is the dotted line. We do the same calculation using the US data. The establishment size distribution for the tradable/investment goods sector (the large-scale sector) is traced with $*$, while the circles ($\circ$) are for the non-tradable sector (the small-scale sector).

Figure 3 shows the establishment size distribution from the calibrated perfect-credit benchmark, and compares it with the US data. The model is able to fit the tails of the empirical distribution, the distance between the two within-sector distributions, and the initial concavity in the overall (inclusive of both sectors) distribution of establishment size. The assumption that productivities for both sectors are drawn from the same Pareto distribution generates the identical slope for the right tails. The model cannot capture the initial concavity in the distribution of establishment size within a sector, however, presumably because we are abstracting from within-sector heterogeneity in fixed costs.

4.2 Results

In this section, we quantify the effect of financial frictions on economic development. We first show that financial frictions have a substantial, adverse impact on per-capita income. In our exercises, the lower per-capita income in economies with financial frictions is mainly explained by their low aggregate TFP, with particularly low productivity in the large-scale sector. These results are consistent with the empirical findings in Section 2.

We vary ϕ—the parameter governing the enforcement of contracts in condition (2)—to span a range of external finance to GDP ratios observed in the data. With quintiles of countries constructed in terms of per-capita income at PPP, external finance to GDP ratio averages 0.1 for the bottom quintile and 2.1 for the top quintile. The equilibrium external finance to GDP ratio is monotonically decreasing in ϕ in our exercises. We use 14 values of ϕ ranging from 0.10 to 0.99, which span variations in external finance to GDP ratios from 0.4 to 2.4. The parameter ϕ itself has no immediate real-world counterpart. Hence we plot variables of interest against the ratio of external finance to GDP implied by a given ϕ.
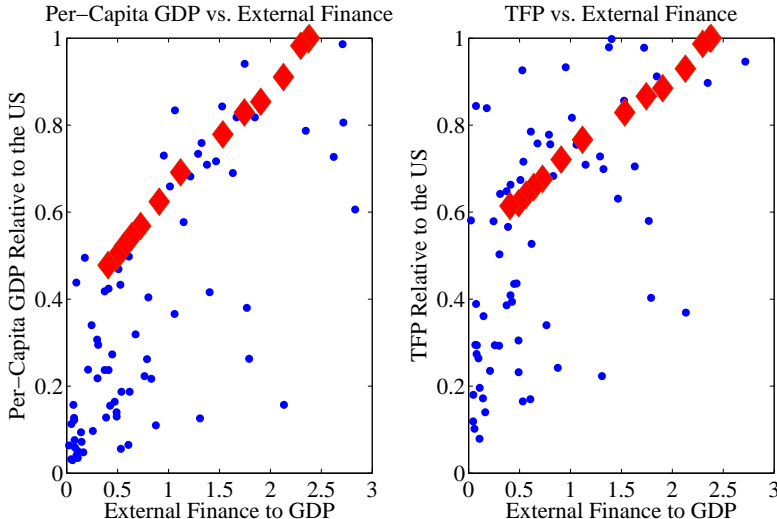

Fig. 4: Per capita GDP at PPP (left panel) and aggregate TFP (right panel) against the ratio of external finance to GDP (horizontal axis). Data (countries, ●) and model (◆).

Aggregate Impact of Financial Frictions Figure 4 plots (using diamonds) the simulated effect of financial frictions on per-capita income at PPP, and on aggregate TFP. Both income and TFP are measured relative to our perfect-credit, US benchmark. The dots in the figure represent data (countries), also relative to the US. In our model, the variation in financial frictions can bring down per-capita income to less than half of the US level. This roughly accounts for the difference between a country like Malaysia and the US, or about 80 per cent of the US-Mexico difference. While this does not come close to the difference

between the US and the poorest countries in sub-Saharan Africa, the magnitude is nevertheless sizable, considering that we are varying one single factor—financial markets—across countries. Furthermore, the factor-of-two difference in per-capita income generated by our quantitative theory goes a long way, if one were to focus on the factor-of-five difference in non-agricultural output per capita between the richest fifth percentile of countries and the poorest fifth percentile.[24]

As in the data, the per-capita income differences in our model are primarily accounted for by differences in TFP (Figure 4, right panel).[25] Financial frictions can reduce aggregate TFP by more than 40 per cent.

Impact on Sectoral Productivity Financial frictions have differential impact on the two sectors. Note that we identify the investment goods and tradable sectors with the large-scale sector, and the non-tradable sector with the small-scale sector. The solid lines in Figure 5 trace the effect of financial frictions on the measured TFP of the small-scale, non-tradable sector (left panel) and the large-scale, tradable sector (right panel). While TFP declines by up to 30 per cent in the small-scale sector, TFP in the large-scale sector declines by more than 50 per cent with financial frictions. This result is consistent with the empirical observation in Section 2 that productivity differences across countries are sharpest for the large-scale sector.

Next, we ask what are the driving forces behind these effects on aggregate and sector-level productivity. Intuitively, financial frictions distort the allocation of productive capital among entrepreneurs in operation. Those with binding collateral constraints will have a marginal product of capital higher than the rental rate. In addition, financial frictions distort the entry and exit of entrepreneurs: Productive-but-poor entrepreneurs delay entry until they can overcome financing constraints, and incompetent-but-wealthy ones remain in business for too long. Here we quantitatively analyze how financial frictions affect sectoral and aggregate productivity by distorting the allocation of capital and the allocation of entrepreneurial talents.

In Figure 5, we decompose the effect of financial frictions on sectoral TFP into their effect on the allocation of capital across active entrepreneurs (intensive margin, or misallocation of capital), and their effect on the allocation of entrepreneurial talents (extensive margin). The extensive margin is further decomposed into the number of active entrepreneurs in each sector, and into the distribution of talent among active entrepreneurs (misallocation of talent). To quantify this decomposition, we perform three experiments on our simulated economies. First, we reallocate capital among active entrepreneurs in each sector to equalize

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[24]See Restuccia et al. (2008) for a decomposition of cross-country per-capita income differences into agricultural and non-agricultural components.

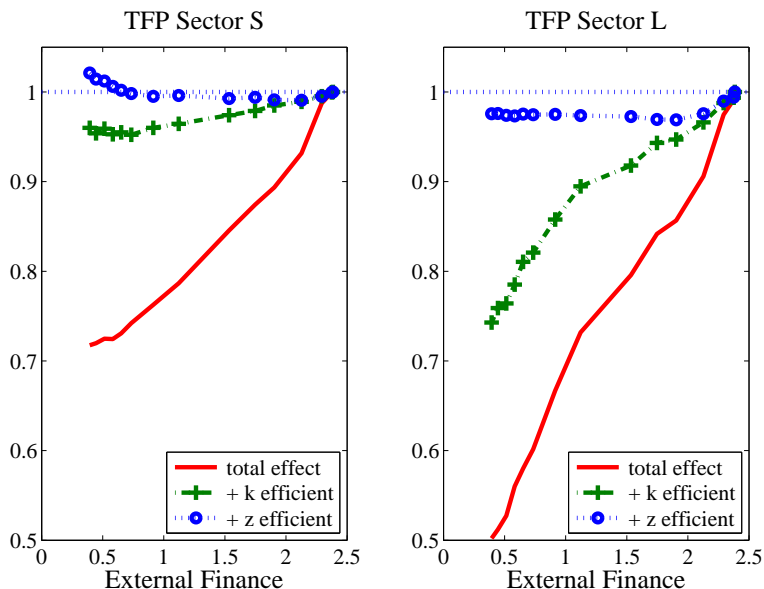[25]TFP is calculated as $A = Y/\left(K^{1/3}L^{2/3}\right)$.

Fig. 5: Decomposing the impact of financial frictions on sectoral TFP in the small-scale sector (left panel) and in the large-scale sector (right panel). Solid lines are the sectoral TFP of simulated economies with financial frictions. TFP is normalized by its level in the perfect-credit benchmark, and plotted against external finance to GDP ratios. Efficient reallocation of capital among existing active entrepreneurs raises the sectoral TFP (dashed-crossed lines). When distortions on selection into entrepreneurship are undone, sectoral TFP further increases (dotted-circled lines).

the marginal product of capital across them. For this experiment, we hold fixed the number and the talent distribution of active entrepreneurs, as well as the total capital and labor employed in each sector. The sectoral TFP after this reallocation is the dashed-crossed lines in both panels. For the small-scale sector, almost all of the lower TFP is explained by the misallocation of capital among active entrepreneurs. For the large-scale sector, this intensive-margin distortion explains only half of the lower TFP.

In the second experiment, while holding fixed the number of active entrepreneurs in each sector, we select the most talented individuals into entrepreneurship. We also allocate capital efficiently across the new set of active entrepreneurs.[26] The resulting sectoral TFP from this reallocation of talent and capital is the dotted-circled lines. The misallocation of talent into entrepreneurship explains about half of the lower TFP in the large-scale sector, and about one sixth of the lower TFP in the small-scale sector.

Finally, in addition to the efficient reallocation of talent and capital above, we allow for the number of entrepreneurs to adjust in each sector at the perfect-credit equilibrium prices. This additional adjustment affects the sectoral TFP only slightly. The dotted-circled lines from the second experiment are already quite close to the horizontal line going through

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[26]For each sector, we pick among the individuals that strictly prefer to be unconstrained entrepreneurs in that sector at the distorted equilibrium prices.

one, which represents the TFP level in the perfect-credit benchmark. This last experiment suggests that restrictions to entry per se may not have significant quantitative effects unless the distribution of entrants is distorted.

The following conclusions can be drawn from these sector-level exercises. Because of their larger investment needs, establishments in the large-scale sector are more susceptible to financial frictions. There are more misallocation of capital and more misallocation of entrepreneurial talent in the large-scale sector than in the small-scale sector. In particular, the distortions on the entry/exit decisions of entrepreneurs matter vastly more for the large-scale sector. This result suggests that modeling endogenous entry/exit of entrepreneurs is pivotal for capturing the large impact of financial frictions on productivity.
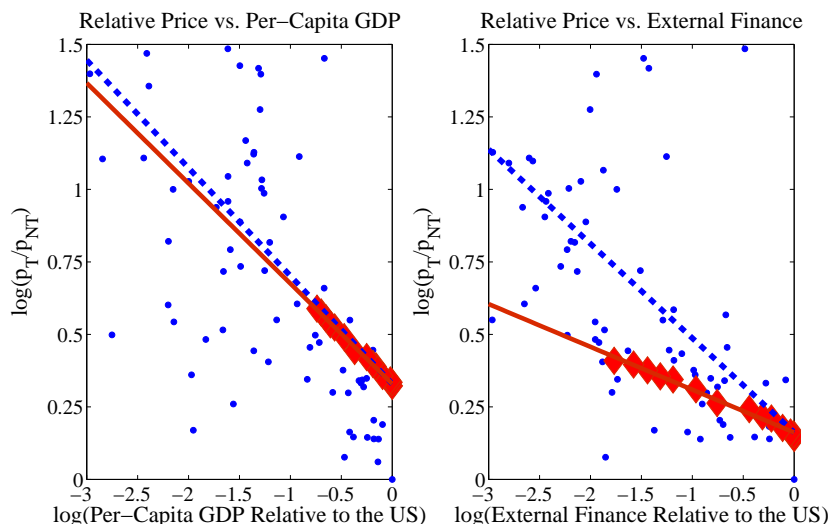

Fig. 6: Relative price of tradables to non-tradables ($\log p_T/p_{NT}$, vertical axis) plotted against log per-capita GDP (left panel) and external finance to GDP ratios (right panel), all relative to the US. Data (countries, •) and model (♦). The dashed lines are the regression line using the data, while the solid lines are the regression and extrapolation line using model simulations.

Relative Productivity and Relative Prices The pattern of relative productivity between the two sectors leads to the price of the large-scale sector relative to the small-scale sector being higher in countries with underdeveloped financial markets. The left panel of Figure 6 uses a log-log scale to plot the relative price of tradables to non-tradables (p_T/p_{NT}) against per-capita GDP (relative to the US).[27] The diamonds represent the model simulations, and the dots represent data (countries). The dashed lines are the regression lines using the data, and the solid lines are the regression (and extrapolation) lines using model simulations. Our baseline calibration explains nearly all (95 per cent) of the implied cross-country

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[27]Note that we calibrate the two sectors of our model to match the scale differences between non-tradables and tradables.

elasticity between the relative price and income per capita. As pointed out in our discussion of Figure 4, financial frictions alone can span only about a factor-of-two variation in income per capita, so all the diamonds are concentrated between -1 and 0. The right panel of Figure 6 uses a log-log scale to plot the relative price of tradables to non-tradables against the ratio of external finance to GDP. Our model explains about half of the elasticity of relative prices with respect to external finance, leaving room for other explanations of relative productivity that are correlated with financial frictions.

Impact on Within-Sector Distribution of Establishment Productivity and Size
In addition to their effects on the relative productivity and relative prices, financial frictions affect the within-sector distributions of establishment-level productivity and size differentially across the two sectors.
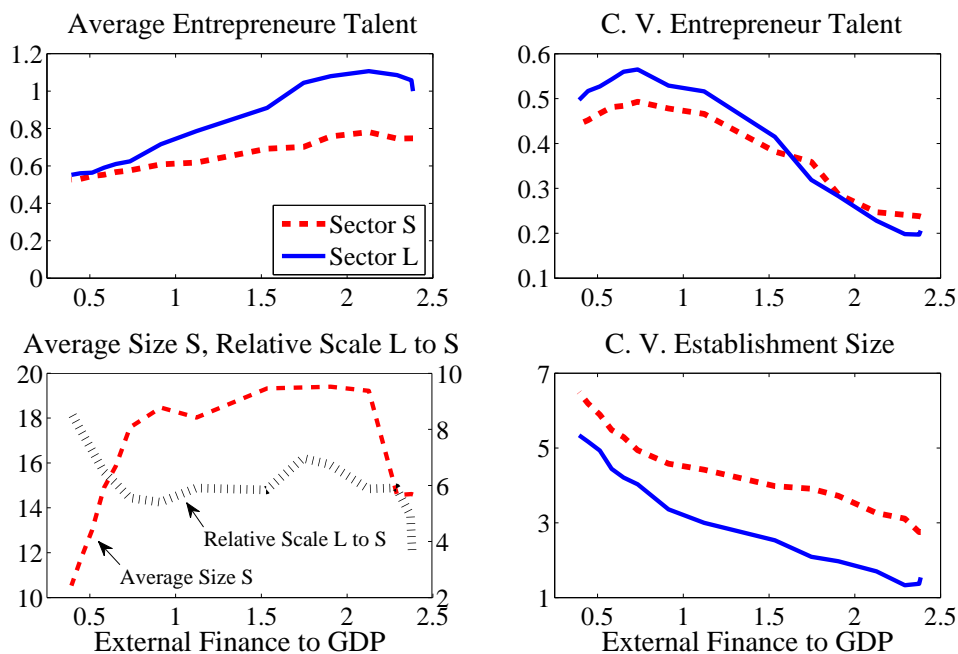

Fig. 7: Impact of financial frictions on the within-sector distributions of establishment-level productivity and size. Clockwise from top left, all plotted against the ratio of external finance to GDP (horizontal axis): Average productivity (z) of active entrepreneurs in the small-scale sector (dashed line) and in the large-scale sector (solid line), normalized by the average large-scale entrepreneurial productivity in the perfect-credit benchmark; Coefficient of variation (c.v.) for the productivity of active entrepreneurs in each sector; Coefficient of variation of the establishment size (number of workers) in each sector; Average establishment size in the small-scale sector (dashed line, left scale) and the ratio of average large-scale sector establishment size to average small-scale sector establishment size (dotted line, right scale).

The top left panel of Figure 7 plots the average talent or productivity (z_j) of active entrepreneurs in the large-scale and the small-scale sectors of our simulated economies,

against the ratio of external finance to GDP. With financial frictions, not only entrepreneurial talent but also an individual's wealth determines whether she will be an entrepreneur or not in any given period. As a result, incompetent-but-wealthy entrepreneurs remain in business, and talented-but-poor individuals do not operate business until they can self-finance the capital needed to operate at a profitable scale. The positive slopes of the two lines (dashed line for small-scale and solid line for large-scale) reflect this distorted selection into entrepreneurship.[28] Furthermore, Figure 5 showed that the misallocation of talent is more rampant in the large-scale sector, which is confirmed here. The average entrepreneurial talent in the large-scale sector drops by more than 40 per cent in response to financial frictions, while its counterpart for the small-scale sector goes down by only 20 per cent.[29]

With more financial frictions, an individual's wealth becomes relatively more influential upon their decisions of entry into and exit from entrepreneurship. As a result, individuals with more diverse entrepreneurial talents will be operating business in any given period. The top right panel of Figure 7 reports this. With more financial frictions (and lower ratios of external finance to GDP), the within-sector distribution of establishment-level productivity (z_j, $j = S, L$) becomes more disperse, increasing the coefficient of variation.

Next, we focus on the lower panels of Figure 7 to explore how financial frictions affect the within-sector establishment size distribution. For given output and factor prices, the size (or the number of workers) of an establishment is determined by the entrepreneurial productivity and the collateral constraint. Therefore, entrepreneurs with the same productivity may operate at different scales, as they may have different levels of wealth (collateral). We have already seen that financial frictions increase the dispersion of the establishment-level productivity (entrepreneurial talent). This is compounded with the increased dispersion of scale for given entrepreneurial talent, and the within-sector establishment size distribution becomes more disperse when there are more financial frictions (Figure 7, bottom right panel). In our model, the dispersion of the overall (inclusive of both sectors) establishment size distribution also increases with financial frictions. This is consistent with the conventional wisdom of a "missing middle" in less developed economies. See Tybout (2000) for a survey.

In the bottom left panel of Figure 7, we trace how the average establishment size of the two sectors changes in response to financial frictions. The dotted line is the ratio of the

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[28]Note that financial frictions decrease the equilibrium ratio of external finance to GDP, which is on the horizontal axis.

[29]Note that the average entrepreneurial talent in the large-scale sector goes up modestly while the ratio of external finance to GDP falls from 2.4 to 2.2. This "positive" selection into entrepreneurship arises from the fact that highly productive entrepreneurs can overcome the collateral constraint more easily than low productivity ones. Firstly, for a given level of output and factor prices, they make more profits. In addition, our financing limit $\bar{k}(\cdot)$ is an increasing function of z. These forces seem to dominate with very mild degrees of financial frictions (high ϕ's), generating the hump in the average entrepreneurial talent in the tradable sector.

average establishment size in the large-scale sector to the average establishment size in the small-scale sector, $\bar{l}_L/\bar{l}_S$ (right-hand side vertical axis). The relative scale of these two sectors increases when there are more financial frictions. The larger scale and more financing needs in the sector with larger fixed costs make it harder to set up an establishment there with financial frictions, reducing the number of these establishments relative to the small-scale sector. At the same time, the relative output price of the large-scale sector goes up with financial frictions. These forces seem to dominate the relatively steeper fall in the average entrepreneurial talent in the large-scale sector (top left panel), and push up the relative scale of these establishments. This is a novel prediction of our model, and is further pursued in the next section.

Of course, our model also has implications on the absolute scale of establishments in each sector. The dashed line in the bottom left panel of Figure 7 is the average establishment size in the small-scale sector (left-hand side vertical axis). As financial frictions get more severe (and the ratio of external finance to GDP falls from 2.4 to 0.4), the average establishment size in the small-scale sector goes from 15 to 19, and finally to 10. In our model, the number of small-scale establishments falls in response to more financial frictions over the range where the ratio of external finance to GDP is between 2.5 and 1.75. This reflects increased difficulty in starting a business even in the small-scale sector, when there are more financial frictions. In addition, factor prices fall in response to more financial frictions. These forces contribute to the scale of 19 workers per establishment, which is larger than that of our perfect-credit, US benchmark. However, with an even higher degree of financial frictions—one comparable to Mexico's, for example, with the ratio of external finance to GDP close to 0.5, the scale of establishments in the small-scale sector is absolutely smaller than in our US benchmark (10 vs. 15). In this region, the dominating force is the low equilibrium wage, which makes more individuals, including those who are not particularly talented, choose entrepreneurship instead. These marginal entrepreneurs overwhelmingly choose to start businesses in the small-scale sector, whose establishment-level technology commands less financing needs. In this sense, financial frictions generate too many establishments that are too small.

Absent from the figure is the average establishment size in the large-scale sector, although it can be easily inferred from the other two series. As financial frictions lower the ratio of external finance to GDP from 2.4 to 0.4, the average establishment size in the large-scale sector goes from 60 to 115, and finally to 80. In our model, financial frictions particularly deter entry into the large-scale sector because of its large financing needs. In addition, factor prices fall in response to financial frictions. These forces lead to an increased establishment size in the large-scale sector. In particular, our model predicts that a country with severe financial frictions will have establishments in the large-scale sector that are on average bigger than those in the US. This is another novel prediction of our model, and on the face of it, it

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seems to defy the conventional wisdom that establishments in less developed countries are on average much smaller than those in advanced economies. However, the overall—inclusive of both sectors—average establishment size of our model economy with financial frictions (the one with an external finance ratio of 0.5) is smaller than that of the perfect-credit benchmark. This is because there are fewer of these large-scale establishments and more of the small-scale establishments in this economy with financial frictions than in the perfect-credit benchmark. We address this model prediction in the next section.

4.3   A Testable Implication

Our exercises confirm the intuition that financial frictions are more harmful to the sector with higher fixed costs, larger scales, and more financing needs (i.e. investment goods and tradables). One novel result is the effect of financial frictions on the average establishment size of sectors in the equilibrium. Financial frictions lead to greater disparity in establishment size between the large-scale sector and the small-scale sector (Figure 7, bottom left panel). As discussed above, this result stems not only from the direct effect of financial frictions on entrepreneurial entry decisions, but also from the general equilibrium effect on wage, capital rental rates, and output prices. With financial frictions, wages go down, and small-scale entrepreneurship becomes more desirable because the opportunity cost—the income from being a worker—is lower. On the other hand, reasonably-able entrepreneurs who have the means to meet the financing needs of large-scale production face relatively higher output prices and lower factor prices, which lead to even larger establishments.

In the real world, many country-specific distortions that we do not consider in our model affect the absolute scale of establishments, particularly in developing countries.[30] For this reason, we first focus on our model prediction on the relative scale of establishments across sectors. Then we revisit our model predictions on how financial frictions affect the absolute scale of sectors.

4.3.1   Cross-Country Analysis of Relative Scale

Evaluating this implication requires data sources for scale that have full coverage and are comparable across countries. The available OECD SSIS is designed for comparability of industries, but its coverage is not well documented: Our concern is that small, informal establishments are not well accounted for in the data. Furthermore, not all countries have complete coverage of industries, and only the US provides both establishment-level and enterprise-level data. We have ten additional countries with comparable data: the three large

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[30]Hsieh and Klenow (2007b) and Guner et al. (2008) highlight the importance of such distortions, for example.

advanced economies (France, Germany, and the UK) and the seven "less-developed" countries available (Czech Republic, Hungary, Korea, Poland, Portugal, Slovakia, and Turkey). Korea and Turkey provide establishment-level data, while the others provide enterprise-level data.[31]

For both measures of scale (workers per enterprise or per establishment), we calculate the average for the tradable and the non-tradable sectors in each country, and take the ratio of the two. Using enterprise-level data, we find that in each of the five less-developed countries, the relative scale of the tradable sector (ranging from 3.4 to 4.1, with a median of 3.8) is larger than in the US (3.1). With establishment-level data, we find much more striking disparities: 10.6 for Korea and 35.0 for Turkey, against 3.7 for the US.[32]

While available OECD data show that the relative size of tradable establishments/enterprieses (to non-tradable ones) is larger in less-developed countries than in the US, these data seem to suffer from coverage issues. We now turn to a case study of the US and Mexico, using data sets with vastly superior comparability and coverage.

4.3.2 A Case Study of the US and Mexico

Data for the US and Mexico allow a more detailed analysis. We use them to revisit our model implication on how financial frictions affect the absolute scale of establishments across sectors. We use Mexico's 1998 National Survey of Micro-Enterprises (ENAMIN) to impute corrections that make the US 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 for the US, and adjustments to add small-scale entrepreneurs without a fixed location, who are included in the US Census (though presumably unimportant) but not for Mexico, where they play an important role. We analyze data at the four-digit level, dropping industries that have a high level of government involvement or provision.[33]

The average establishment size is substantially smaller in Mexico than in the US (7 vs. 16 workers per establishment overall), particularly in non-tradables: retail, transportation,

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[31]The data are for 2002. When not available, we use those for 2001 or 2003. Data on three additional advanced economies (Australia, Canada, and Japan) and one additional "less-developed" country (Mexico) lacked coverage of too many sectors of the economy. 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.

[32]We also considered classifying industries into large-scale vs. small-scale sectors. For a given industry, we compute its average workers per enterprise in France, Germany, the UK and the US. This quantity is used to sort industries into the large-scale sector and the small-scale sector. The results are consistent with our findings based on tradable vs. non-tradable sectors: The relative size of enterprises/establishments in the large-scale sector to those in the small-scale sector is bigger in the less-developed economies than in the rich economies.

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

and construction, for example. Comparison of non-tradables at a more detailed level is not possible, unfortunately, since the US and Mexican classification schemes do not correspond at a further disaggregated level for non-tradables.
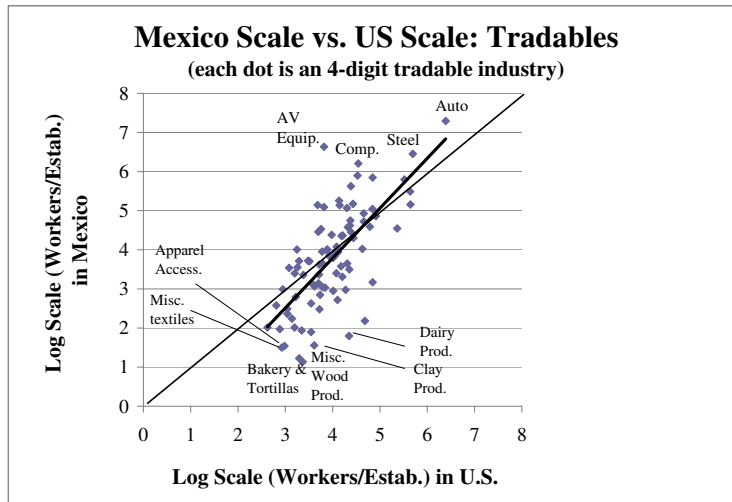
Mexico Scale vs. US Scale: Tradables
(each dot is an 4-digit tradable industry)

Fig. 8: Average establishment size in a given industry in Mexico (logarithmic vertical axis) against that in the US (logarithmic horizontal axis). 88 industries in the tradable sector.

Tradables, however, show perfect correspondence between the two countries, a goal of the NAICS system. In the tradable sector, many industries have larger average establishment size in Mexico than in the US (those lying above the 45-degree line in Figure 8), although on average Mexican tradables establishments are smaller than those in the US. Figure 8 plots the average establishment size (workers per establishment) of a given industry in Mexico (logarithmic vertical axis) against that in the US (logarithmic horizontal axis) for 88 four-digit industries in the tradable sector. The data show a slope that is clearly steeper than the 45-degree line. That is, within the tradable sector, the industries that are of a large scale in the US are even larger in Mexico, while those that are small scale in the US are even smaller in Mexico. The regression coefficient is 1.27 with a standard error of 0.14. This finding is consistent with our simulation results on absolute scale of establishments. In addition, the fact that, at the disaggregated industry level, Mexico has wider variation of scale than the US is consistent with the model's prediction of a higher coefficient of variation of establishment size for financially less developed countries (Figure 7, bottom right panel). Testing this prediction, however, would require more detailed establishment-level data.

To summarize, one of our model predictions in Section 4.2 is that, in an economy with

financial frictions, the large-scale sector has an even larger average establishment size, and the small-scale sector has an even smaller average establishment size, when compared to the perfect-credit benchmark. This implication on absolute scale in the tradable vs. non-tradable context is rejected: The tradables establishments in Mexico are on average smaller than those in the US. However, at a more disaggregated level, using comparable establishment-level data, we have shown that large-scale industries tend to have an even larger average establishment size in Mexico than in the US, while small-scale industries have an even smaller average establishment size in Mexico than in the US. This finding, hitherto undocumented in the literature, renders some support to our model implication on absolute scale across sectors. Another conclusion we draw from this case study is that our mechanism, in which scale difference induces differential impact of financial frictions across sectors, will also work at a more disaggregated level, not just for the tradable vs. non-tradable dichotomy.

4.4   Robustness

We briefly discuss the robustness of our results to alternative model specifications. We first consider other ways of generating scale differences between the two sectors. We have constructed numerical examples for a version of our model where the sectoral scale difference is driven by one-time setup costs, rather than by per-period fixed costs.[34] While these numerical examples were not precisely-calibrated exercises, we found that financial frictions have an even larger impact on aggregate and sectoral productivity, reflecting the stronger non-convexity that (front-loaded) setup costs impose. We chose our fixed-cost specification to avoid the risk of exaggerating the impact of financial frictions, especially when there are no reliable data on setup costs.[35]

We have also considered the possibility that the sectoral scale difference hinges on the establishment-level span of control. In particular, we set α_j and θ_j, $j = S, L$, such that $\alpha_S + \theta_S < \alpha_L + \theta_L$, while the ratio α_j/θ_j is the same for $j = S, L$. The latter assumption reflects the empirical facts on factor shares reported in Table 1. In calibrated exercises with span-of-control differences and no fixed cost in either sector, we find that the effects of financial frictions are broadly consistent with our findings in Section 4.2, although not as

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[34]In the recursive formulation of this specification, we need to carry an additional state variable indicating whether in the previous period an individual was a worker, an entrepreneur in the S sector, or an entrepreneur in the L sector. More important, we allow for between-periods borrowing, i.e., $\underline{a} < 0$. We assume that debt contracts are contingent on idea shocks such that the debt of those entrepreneurs hit with an idea shock (with probability $1 - \gamma$) at the end of a period is forgiven. The lower bound on asset $\underline{a}$ is defined to be the most generous debt limit that is enforceable when the borrower is not hit with an idea shock. The zero-profit condition of the financial intermediary will determine the spread between the deposit and the borrowing rates.

[35]See, for example, Paulson and Townsend (2004) and McKenzie and Woodruff (2006) for discussions on setup and fixed costs for small establishments in developing countries. Sutton (1991) explains the difficulties of estimating setup costs using data from oligopolistic industries in developed countries.

large in magnitude. One important distinction is the implication on how relative scale of the two sectors responds to financial frictions. With span-of-control differences, the relative scale of the two sectors (L to S) decreases with financial frictions. Recall that our model with fixed cost differences predicts the opposite, consistent with our empirical findings in Section 4.3. It is mainly for this reason that we chose the fixed-cost model for our analysis.

Finally, we have also tried an alternative specification for the collateral constraint: a capital rental limit that does not depend on the entrepreneurs' talent z. More specifically, the sum of the capital rental and the fixed cost could not exceed λa, where λ is a parameter governing the degree of financial frictions, and a is the financial wealth of an entrepreneur at the beginning of a period. Note that $\lambda = 1$ corresponds to financial autarky, and that $\lambda \to +\infty$ to the perfect-credit benchmark. In calibrated exercises with this simpler collateral constraint, the results are very similar to our results in Section 4.2, both qualitatively and quantitatively. One nice feature of this specification is that the absolute scale (average workers per establishment) of small-scale sector establishments are monotonically decreasing in the degree of financial frictions, unlike the hump in the bottom left panel of Figure 7. We nevertheless decided to go with a more general specification where collateral constraints are determined by both entrepreneurs' financial wealth and talent.

5 Concluding Remarks

We have developed a quantitative theory linking countries' level of financial development to their per-capita GDP, aggregate TFP, relative productivity and prices across sectors. Financial frictions distort the allocation of capital and entrepreneurial talents, and are found to have sizable effects on a country's output per worker and aggregate productivity. The sectors characterized by large fixed costs at the establishment level operate most efficiently at larger scales, and hence have bigger financing needs. For this reason, they are more vulnerable to financial frictions than small-scale sectors. We have shown that this mechanism is quantitatively important, explaining half of the observed relationship between financial development and relative productivity of sectors in the data. We have also shown that our mechanism is also consistent with the larger differences in average establishment sizes across sectors observed in financially less developed countries.

Our analysis shows how micro-level (firm or establishment) technological differences across sectors help us better understand macroeconomic issues such as relative productivity and relative prices. In this context, we view the study of other micro-level distortions—e.g. size-dependent policies of Guner et al. (2008), and entry barriers of Djankov et al. (2002)— and their interaction with financial frictions as promising avenues for future research.

Proof of Proposition 1 The rental of capital k in sector j is enforceable iff:

$$\tilde{v}^j (k; a, z) \geq v^d (a^d, z), \tag{6}$$

where $\tilde{v}^j (k; a, z)$ is the value of a non-defaulting entrepreneur with wealth a and ability z that operates in sector j with rented capital k:

$$\tilde{v}^j (k; a, z) = \max_{c, a'} \{u (c) + \beta [\gamma v (a', z) + (1 - \gamma) \mathbb{E}_{z'} v (a', z')]\}$$

$$\text{s.t. } pc + a' \leq \max_l \{p_j z_j f (k, l) - wl\} - Rk - (1 + r) p_j \kappa_j + (1 + r) a.$$

We define $v^d (a^d, z)$ to be the value of a defaulting entrepreneur with ability z who gets to keep $a^d = (1 - \phi) [\max_l \{p_j z_j f (k, l) - wl\} + (1 - \delta) k]$:

$$v^d (a^d, z) = \max_{c, a'} \{u (c) + \beta [\gamma v (a', z) + (1 - \gamma) \mathbb{E}_{z'} v (a', z')]\}$$

$$\text{s.t. } pc + a' \leq (1 - \phi) \left[\max_l \{p_j z_j f (k, l) - wl\} + (1 - \delta) k \right].$$

It is straightforward to see that $\tilde{v}^j (k; a, z) \geq v^d (a^d, z)$ iff:

$$\max_l \{p_j z_j f (k, l) - wl\} - Rk - (1 + r) p_j \kappa_j + (1 + r) a \geq (1 - \phi) \left[\max_l \{p_j z_j f (k, l) - wl\} + (1 - \delta) k \right],$$

which is equivalent to:

$$(1 + r) (a - p_j \kappa_j) \geq (1 - \phi + r + \phi \delta) k - \phi \max_l \{p_j z_j f (k, l) - wl\}.$$

As long as $\lim_{k \to 0} f_k (k, l) = \infty$ and $\lim_{k \to \infty} f_k (k, l) = 0$, there exists a unique function $\bar{k}^j (a, z_j; \phi)$ defined implicitly by:

$$(1 + r) (a - p_j \kappa_j) = (1 - \phi + r + \phi \delta) \bar{k}^j (a, z_j; \phi) - \phi \max_l \{p_j z_j f (\bar{k}^j (a, z_j; \phi), l) - wl\}.$$

It is straightforward to see that $\bar{k}^j (a, z_j; \phi)$ is strictly increasing in a, z_j, and ϕ. ∎

Proof of Proposition 2 In an economy with perfect credit markets, selection of individuals into entrepreneurship and sectors is determined by their entrepreneurial talents and relative prices. In particular, there exist two threshold ideas $\hat{z}_j$, $j = S, L$, and a function $\hat{z}_j (z_{-j})$, $(j, -j) = (S, L), (L, S)$, dividing the space of entrepreneurial ideas (z_S, z_L) into workers and entrepreneurs in the S and L sectors. These thresholds are defined by the following three indifference conditions:

$$(p_j \hat{z}_j)^{\frac{1}{1-\alpha-\theta}} \left(\frac{\alpha}{R} \right)^{\frac{\alpha}{1-\alpha-\theta}} \left(\frac{\theta}{w} \right)^{\frac{\theta}{1-\alpha-\theta}} (1 - \alpha - \theta) = w + p_j \kappa_j, \quad s = S, L, \tag{7}$$

$$(p_j \hat{z}_j (z_{-j}))^{\frac{1}{1-\alpha-\theta}} \left(\frac{\alpha}{R}\right)^{\frac{\alpha}{1-\alpha-\theta}} \left(\frac{\theta}{w}\right)^{\frac{\theta}{1-\alpha-\theta}} (1-\alpha-\theta) - p_j \kappa_j$$

$$= (p_{-j} z_{-j})^{\frac{1}{1-\alpha-\theta}} \left(\frac{\alpha}{R}\right)^{\frac{\alpha}{1-\alpha-\theta}} \left(\frac{\theta}{w}\right)^{\frac{\theta}{1-\alpha-\theta}} (1-\alpha-\theta) - p_{-j}\kappa_{-j}. \tag{8}$$

Integrating over individual output of entrepreneurs in sector j net of fixed costs, we obtain an expression for the net output of sector j,

$$Y_j = N \int_{\hat{z}_j}^{\infty} \int_0^{\hat{z}_{-j}(z_j)} z_j k(z)^\alpha l(z)^\theta \mu(dz) - \kappa_j N \int_{\hat{z}_j}^{\infty} \int_0^{\hat{z}_{-j}(z_j)} \mu(dz). \tag{9}$$

Using $k(z) = \frac{z^{\frac{1}{1-\alpha-\theta}}}{Z_j^{\frac{1}{1-\alpha-\theta}}} \frac{K_j}{N}$ and $l(z) = \frac{z^{\frac{1}{1-\alpha-\theta}}}{Z_j^{\frac{1}{1-\alpha-\theta}}} \frac{L_j}{N}$, which follow from the first order conditions of the firms' problem, we can rewrite (9) as:

$$Y_j = N \int_{\hat{z}_j}^{\infty} \int_0^{\hat{z}_{-j}(z_j)} z_j \left[\frac{z_j^{\frac{1}{1-\alpha-\theta}}}{Z_j^{\frac{1}{1-\alpha-\theta}}} \frac{K_j}{N_j} \right]^\alpha \left[\frac{z_j^{\frac{1}{1-\alpha-\theta}}}{Z_j^{\frac{1}{1-\alpha-\theta}}} \frac{L_j}{N_j} \right]^\theta \mu(dz) - \kappa_j N \int_{\hat{z}_j}^{\infty} \int_0^{\hat{z}_{-j}(z_j)} \mu(dz)$$

$$= \frac{N^{1-\alpha-\theta} K_j^\alpha L_j^\theta}{Z_j^{\frac{\alpha+\theta}{1-\alpha-\theta}}} \int_{\hat{z}_j}^{\infty} \int_0^{\hat{z}_{-j}(z_j)} z_j^{\frac{1}{1-\alpha-\theta}} \mu(dz) - \kappa_j N \int_{\hat{z}_j}^{\infty} \int_0^{\hat{z}_{-j}(z_j)} \mu(dz).$$

Then,

$$Y_j = N^{1-\alpha-\theta} K_j^\alpha L_j^\theta Z_j - \kappa_j N \int_{\hat{z}_j}^{\infty} \int_0^{\hat{z}_{-j}(z_j)} \mu(dz), \tag{10}$$

where $Z_j = \left[\int_{\hat{z}_j}^{\infty} \int_0^{\hat{z}_{-j}(z_j)} z_j^{\frac{1}{1-\alpha-\theta}} \mu(dz) \right]^{1-\alpha-\theta}$.

Assuming $\mu(dz) = \eta^2 (z_S z_L)^{-(\eta+1)}$ and that entrepreneurs are a small fractions of the population (i.e., $\hat{z}_j$ is large for $j = S, L$), we obtain

$$Z_j = \left[\int_{\hat{z}_j}^{\infty} \int_0^{\hat{z}_{-s}(z_j)} z^{\frac{1}{1-\alpha-\theta}} \mu(dz) \right]^{1-\alpha-\theta} \approx \left[\int_{\hat{z}_j}^{\infty} z^{\frac{1}{1-\alpha-\theta}} \eta z_j^{-(\eta+1)} dz_j \right]^{1-\alpha-\theta},$$

$$\int_{\hat{z}_j}^{\infty} \int_0^{\hat{z}_{-j}(z_j)} \mu(dz) \approx \hat{z}_j^{-\eta}.$$

Using (7), $\frac{\alpha}{R} = \frac{K_j^{1-\alpha}}{L_j^\theta} \frac{1}{p_j Z_j}$ and $\frac{\theta}{w} = \frac{L_j^{1-\theta}}{K_j^\alpha} \frac{1}{p_j Z_j}$, we obtain

$$\hat{z}_j = \left\{ \frac{\left(\kappa_j + \frac{w}{p_j}\right) \left[\frac{(1-\alpha-\theta)}{\eta(1-\alpha-\theta)-1} \eta \right]^{\alpha+\theta}}{(1-\alpha-\theta) N^{-\alpha-\theta} K_j^\alpha L_j^\theta} \right\}^{\frac{1}{1+\eta(\alpha+\theta)}}. \tag{11}$$

Substituting into (10),

$$Y_j = A_j N^{\frac{1}{1+\eta(\alpha+\theta)}} K_j^{\frac{\alpha\eta}{1+\eta(\alpha+\theta)}} L_j^{\frac{\theta\eta}{1+\eta(\alpha+\theta)}},$$

where

$$A_j = \frac{\left[\frac{(1-\alpha-\theta)}{\eta(1-\alpha-\theta)-1}\eta\right]^{\frac{1}{1+\eta(\alpha+\theta)}} \left[1 - \frac{p_j\kappa_j}{p_j\kappa_j+w}\left(1-\alpha-\theta-\frac{1}{\eta}\right)\right]}{\left[\frac{p_j\kappa_j}{w}+1\right]^{\frac{\eta(1-\alpha-\theta)-1}{1+\eta(\alpha+\theta)}}}. \quad \blacksquare$$

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

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

Thus,

$$\Pr\left[\tilde{l}_j > l\right] = P\left[\left(\frac{z}{\hat{z}_j}\right)^{\frac{1}{1-\alpha-\theta}} l(\hat{z}_j) > l\right] = P\left[z > \left(\frac{l}{l(\hat{z}_j)}\right)^{1-\alpha-\theta} \hat{z}_j \,\middle|\, z \geq \hat{z}_j\right] = \left(\frac{l(\hat{z}_j)}{l}\right)^{\eta(1-\alpha-\theta)}.$$

The aggregate establishment size distribution in the economy is then given by a mixture of Pareto distributions:

$$\Pr\left[\tilde{l}_j > l\right] = n_S\left(\frac{l(\hat{z}_S)}{l}\right)^{\eta(1-\alpha-\theta)} + n_L\left(\frac{l(\hat{z}_L)}{\max\{l, l(\hat{z}_L)\}}\right)^{\eta(1-\alpha-\theta)}, \quad l \geq l(\hat{z}_S).$$

Finally, by integrating $l(z) = \frac{z^{\frac{1}{1-\alpha-\theta}}}{Z_j^{\frac{1}{1-\alpha-\theta}}}\frac{L_j}{N}$ over z, we calculate the average establishment size in sector j:

$$\bar{l}_j = \frac{L_j}{N(1-\mu(\hat{z}_j))}. \tag{12}$$

The optimal allocation of labor L_j and entrepreneurs $N(1-\mu(\hat{z}_j))$ to sector j implies:

$$\theta p_j N^{1-\alpha-\theta} Z_j K_j^\alpha L_j^{\theta-1} = w, \tag{13}$$

$$(1-\alpha-\theta) p_j N^{-\alpha-\theta} Z_j K_j^\alpha L_j^\theta = p_j\kappa_j(1-\mu(\hat{z}_j)) + w\mu(\hat{z}_j). \tag{14}$$

Taking the ratio of these two conditions, we obtain:

$$\frac{1-\alpha-\theta}{\theta}\frac{L_j}{N(1-\mu(\hat{z}_j))} = (1-\gamma)\frac{p_j\kappa_j}{w} + \frac{\mu(\hat{z}_j)}{1-\mu(\hat{z}_j)}. \tag{15}$$

Substituting (14) into (11), we obtain:

$$\hat{z}_j = \left\{\frac{\left(\kappa_j + \frac{w}{p_j}\right)\left[\frac{(1-\alpha-\theta)}{\eta(1-\alpha-\theta)-1}\eta\right]^{\alpha+\theta}}{\frac{p_j\kappa_j(1-\mu(\hat{z}_j))+\frac{w}{p_j}\mu(\hat{z}_j)}{Z_j}}\right\}^{\frac{1}{1+\eta(\alpha+\theta)}}, \tag{16}$$

$$\frac{p_j\kappa_j}{w} + \frac{\mu(\hat{z}_j)}{1-\mu(\hat{z}_j)} = \left[\frac{p_j\kappa_j}{w} + \frac{\mu(\hat{z}_j)}{1-\mu(\hat{z}_j)}\right]\frac{\eta(1-\alpha-\theta)-1}{\eta(1-\alpha-\theta)}. \tag{17}$$

Combining (12), (15) and (17), we obtain the desired expression:

$$\frac{\bar{l}_j}{\bar{l}_{j'}} = \frac{p_j\kappa_j+w}{p_{j'}\kappa_{j'}+w}. \quad \blacksquare$$

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