University of Toronto
Department of Economics

Working Paper 537

Misallocation, Establishment Size, and Productivity

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April 18, 2015

Misallocation, Establishment Size, and Productivity[†]

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April 2015

Abstract

We construct a new dataset using census, survey, and registry data from hundreds of sources to document a clear positive relationship between development and average establishment size in manufacturing across 134 countries. We rationalize this relationship using a standard model of reallocation among production units that features endogenous entry and productivity investment. The model connects small operational scales to the prevalence in poor countries of correlated distortions (the elasticity between wedges and establishment productivity). The model also rationalizes the finding in poor countries of low establishment-level productivity and low aggregate productivity investment. A calibrated version of the model implies that when correlated distortions increase from 0.09 in the U.S. to 0.5 in India, establishment size and establishment-level productivity fall by more than 82 percent and aggregate productivity falls by around 70 percent. Relative to the existing literature, these substantial size and productivity effects are more in line with cross-country data.

Keywords: misallocation, establishment size, productivity, investment, idiosyncratic distortions.
JEL codes: O1, O4.

[†]We thank David Atkin, Nick Bloom, Margarida Duarte, Peter Klenow, Michael Peters, Xiaodong Zhu, and several seminar and conference participants for helpful comments. All errors are our own. Restuccia gratefully acknowledges the financial support from the Social Sciences and Humanities Research Council of Canada.

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1 Introduction

A consensus view in the literature has emerged where the large variations in income per capita across countries are mostly explained by differences in total factor productivity (TFP). A potential explanation for these productivity differences is the (mis)allocation of factors of production among heterogeneous production units that differs across countries. An important finding in the empirical literature on misallocation is that not only is there evidence of large aggregate effects from factor misallocation across heterogeneous production units (e.g. Hsieh and Klenow, 2009), but also that there are substantial cross-country differences in establishment-level productivity and investment in intangible capital.[1] What explains the differences in establishment-level and aggregate productivity across countries? We address this question through a standard model of reallocation with heterogeneous production units that features an investment decision on establishment-level productivity and an entry decision. The model connects two pieces of empirical evidence which we document—the prevalence of correlated distortions and the smaller operational scale of production units in poor countries—to explain low establishment-level productivity and hence low aggregate productivity. The contribution of low establishment productivity to aggregate productivity is in addition to and quantitatively as large as the standard effect of factor misallocation on aggregate productivity.

Evidence of the relationship between development and establishment size has been both sparse and inconclusive due to the lack of standardized size data for a large group of countries.[2] We address this by constructing a standardized database on establishment and firm sizes based on individual-country data from manufacturing censuses, surveys, and registries. Using hundreds of separate sources, we have assembled data for 134 countries with comparable employment-size data. In contrast to Alfaro et al. (2009) and Bollard et al. (2014), who use international

[1] See for instance Hsieh and Klenow (2009), Bloom and Van Reenen (2010), Bloom et al. (2010), Pagés-Serra (2010), Gal (2013), Bloom et al. (2013), among others for evidence of firm-level productivity differences across countries and Corrado et al. (2012) for cross-country differences in intangible capital.

[2] Poschke (2014) reports a positive relationship between size and development, while Alfaro et al. (2009) and Bollard et al. (2014) find the opposite relationship. We discuss this further in Section 2.

data plagued by cross-country differences in the size of sampled firms, we show that average establishment size is strongly positively correlated with GDP per capita. For instance, whereas average establishment size in U.S. manufacturing is 22 workers, in Benin and Sierra Leone it is about 2 workers, an 11-fold difference. As a summary measure of the relationship between development and size, we compute the income elasticity of establishment size to be 0.29. Large differences in operational scales are also found in other sectors such as agriculture from Census data where the operational scale of farms in rich countries is 34 times that of poor countries (see for instance Adamopoulos and Restuccia, 2014). Our data confirms the finding in Poschke (2014) where survey data on entrepreneurs and financial data for large firms are shown to imply a similar positive income elasticity of size across 43 countries.

We consider a standard model of heterogeneous production units that builds from Hopenhayn (1992). For comparability, the setup follows closely the monopolistic competition framework used in the empirical analysis of Hsieh and Klenow (2009). The basic framework is extended along two important dimensions in order to address differences in entry and establishment-level productivity. We incorporate an endogenous entry decision of establishments as well as an endogenous investment decision on establishment-level productivity by entrants. There is a large number of potential entrants that draw their idiosyncratic productivity from a known distribution at a cost. Establishments can improve their productivity through investment, but only before the realization of their idiosyncratic productivity. In the theory, ex-ante identical entering establishments make the same productivity investment decision but are ex-post heterogeneous in their idiosyncratic productivity. The theory connects policy distortions, institutions, and frictions that discourage establishment-level investment. The key emphasis in the model is the extent to which distortions that effectively penalize more productive relative to less productive establishments—what Restuccia and Rogerson (2008) call correlated idiosyncratic distortions—discourage productivity investment by all establishments. The set of policies and institutions that effectively create correlated idiosyncratic distortions is very large and has been extensively discussed in the literature.[3] In the model, we show there is a strong connection between the extent of correlated distortions, establishment-level productivity, and the mass of entrants in the economy. These effects work to lower establishment size, establishment-level productivity, and aggregate productivity. By keeping close to the analysis in Hsieh and Klenow (2009), we are able to explicitly decompose the effects of distortions into those working through the investment channel emphasized in our paper with those working through the standard factor misallocation channel analyzed in the literature.

We calibrate a benchmark economy to U.S. data and show that reasonable variations in the extent of correlated distortions across countries have substantial negative effects on establishment size, establishment-level productivity, and aggregate output per capita. In particular, compared to the calibrated U.S. benchmark economy, increasing correlated distortions to 0.5, the elasticity between wedges and establishment productivity in India, generates a reduction in establishment size from 22 workers in the U.S. benchmark to 2.8 workers, which represents an 87 percent reduction in average establishment size and a factor difference in average establishment size between the U.S. and India of 7.9. The increase in correlated distortions generates a reduction in establishment-level productivity of similar magnitude, 82 percent, which together with the effect of factor misallocation implies a factor difference in aggregate TFP of 3.2. To put it differently, in this experiment, a 1.6-fold difference in aggregate productivity between the U.S. and India generated by factor misallocation is amplified into a total 3.2-fold difference in aggregate productivity due to the added reduction in establishment-level productivity.[4] Our quantitative results show that the productivity effects of the investment channel are as important as the effects of distortions on factor misallocation. Moreover, relative to the existing literature, our framework generates large size and productivity effects that are more in line with

[3]See Restuccia and Rogerson (2013) and Hopenhayn (2014) for discussions of these policies and institutions. Some examples are small business subsidies, financial constraints, trade restrictions, and the ability of establishments to remain informal to avoid taxes.

[4]Interestingly, our parsimonious measure of correlated distortions generates a reduction in aggregate TFP from factor misallocation that compares in magnitude to the estimates in Hsieh and Klenow (2009) for India using detailed firm-by-firm wedges, suggesting that our summary measure of distortions captures the bulk of their effects on factor misallocation.

the cross-country data.

To assess the ability of correlated distortions to quantitatively explain productivity differences across a larger set countries, we document evidence from cross-country micro data for the elasticity between distortions (wedges) and establishment productivity, using establishment-level data from the World Bank's Enterprise Surveys. We show that the elasticity of distortions with respect to productivity in the micro data is strongly negatively related to both average establishment size and GDP per capita across 63 countries.

We emphasize that with no endogenous investment in establishment productivity, the model would imply no differences in establishment productivity and establishment size from factor misallocation. As a result, the investment channel not only amplifies the losses in output and productivity from misallocation, but also rationalizes the impact of distortions on establishment size as observed in the cross-country data.[5] To the extent that misallocation is reduced within a country over time, the model also contributes to understanding trends in establishment size. In the United States, for example, Poschke (2014) reports a doubling of average firm size since the early twentieth century, while the results in Ziebarth (2013) and Hsieh and Klenow (2009) suggest a significant reduction in misallocation in the U.S. over the same time period.

Our paper is closely related to the broad literature on misallocation and productivity.[6] In particular, within this literature we relate to papers studying the impact of policies and institutions generating misallocation that also induce disincentives for establishments to invest in productivity. Early examples of this literature are Restuccia (2013a) and Bello et al. (2011) with more elaborate analysis in Ranasinghe (2014), Bhattacharya et al. (2013), Gabler and Poschke (2013), and Da-Rocha et al. (2014), among others. Our paper is closest to Hsieh and Klenow (2014) who introduce correlated distortions into an economy where establishments invest in productivity over their life cycle (step-by-step innovation). Their model generates qualitative

[5]See for instance the related work of Hopenhayn (2013) emphasizing the potential importance of establishment size in generating substantial differences in productivity from specific distortionary policies.

[6]See for instance the surveys of this literature in Restuccia and Rogerson (2013), Restuccia (2013b), and Hopenhayn (2014).

implications that are similar to ours. Our parsimonious representation of correlated distortions and productivity investment by establishments allows us to derive closed-form expressions for the impact of correlated distortions on establishment size and aggregate TFP and to separate the effects of distortions working through the investment and factor misallocation channels. This allows us to provide a more disciplined quantitative evaluation of the model as well as to analyze the source of the dramatic quantitative differences between the effects of correlated distortions in our paper relative to those in the literature.

In generating differences in establishment size, our work is closely related to the seminal work of Lucas (1978) who showed that an elasticity of substitution less than one may be needed in the production function between capital and labor in order to rationalize the larger operational scales in rich countries. In our framework, even with Cobb-Douglas technology, establishment size can vary with correlated distortions. The view that differences in size across countries can arise from distortions shares with the work of Guner et al. (2008) who emphasize size-dependent distortions, i.e., distortions such as a taxes and regulations that apply only beyond a threshold size in terms of the number of workers in the firm. We differ from Guner et al. in that in our framework any correlated distortion causes productivity at the establishment level to drop for all establishments, adding to the potential factor misallocation effects typically emphasized in the literature. For this reason, the size and productivity impact of correlated distortions in our framework are orders of magnitude larger than those emphasized in Guner et al. (2008). The literature has also explored many specific policies thought to explain income differences across countries such as firing costs, entry costs, or average tax rates. But in the standard framework all these policies will lead to *larger* establishment sizes in poor countries.[7] To the extent that poor countries have both harmful policies *and* correlated distortions, this paper helps to rationalize why establishments are smaller in countries with higher average costs of doing business.

[7]See for instance Hopenhayn and Rogerson (1993), Barseghyan and DiCecio (2011), and Moscoso-Boedo and Mukoyama (2012), among others.

The paper is organized as follows. In the next section, we present the facts from our constructed dataset of 134 countries to establish that establishment size increases substantially with the level of development across countries. Section 3 presents the model and characterizes the qualitative implications. In Section 4, we calibrate the model to data for the United States and show the quantitative implications of the model for hypothetical variations in the extent of correlated distortions. We then construct and document measures of correlated distortions across countries and assess their potential to generate differences in size and productivity. We also discuss our results for reasonable extensions in the model and reasonable variations in key parameter values. We conclude in Section 5.

2 Average Establishment Size across Countries

We construct a dataset for the average employment size of manufacturing establishments and firms across countries between 2000 and 2012 using hundreds of reports from economic censuses and surveys which use comprehensive business registries to create sampling frames.[8] We include all countries with publicly available data representative of all manufacturing establishments or firms.[9] Not included in the data are businesses without a fixed location. Businesses operating out of households are generally included only if signs are posted on the premises.[10]

Our standardized definition of size is the average number of persons engaged per establishment (defined as a physical location where economic activity takes place), but different countries report statistics using different definitions. Some countries report the number of active establishments and firms (where a firm is a collection of establishments under common ownership),

[8]In the appendix we provide greater detail about how we construct the dataset, a list of the countries included, and a list of the sources we use for each country.

[9]The dataset also includes all territories such as French Guiana, Hong Kong, and Puerto Rico. We use the word 'country' solely for ease of exposition.

[10]The sole exception to this rule is the United States. Although U.S. employer data uses a standard definition of 'establishment,' the data for non-employers (i.e., self-employed) includes businesses with no fixed location like food trucks or sub-contractors in construction. Our focus on manufacturing should prevent this from being an issue, but our reported employment size for the U.S. may as a result be slightly biased downwards.

while other countries report only one or the other. Three definitions of employment are also used: persons engaged (paid and unpaid), average number of employees (including full-time and part-time paid workers), and full-time equivalent employees. In the appendix we explain in detail how we use these data to construct our standardized measure. Throughout the data-collection process, we have made an effort to search for evidence from methodology documents and other published reports that small establishments are not included. Any country for which such evidence exists is not included in our sample.

It is worth digressing at this point to note that accounting for establishments without paid employees is crucial when investigating differences in establishment size across rich and poor countries, as these establishments (which often employ unpaid family members) account for a significant portion of establishments in poor countries. In Sierra Leone, for example, 83 percent of establishments have no paid employees, and in Ghana, unpaid workers account for almost half of the manufacturing workforce. As a result, excluding non-employer establishments would generate a highly distorted picture of cross-country establishment size differences.

In our final dataset, persons engaged per establishment is averaged over all years for each of the 134 countries.[11] Table 1 reports some descriptive statistics concerning average establishment size, GDP per capita, and population.[12]

Figure 1 shows average establishment size for 134 countries in relation to GDP per capita. The data clearly show a positive correlation between average establishment size and GDP per capita. In particular, the elasticity of establishment size with respect to GDP per capita is 0.29. Figure 2 shows that the correlation between size and income is even stronger if we omit

[11] Although size data is available for Norfolk Island, it has been dropped for lack of any reliable measure of GDP per capita.

[12] GDP per capita (adjusted for purchasing power parity, PPP) is from Penn World Table v. 8.0 for 105 countries, the IMF's World Economic Outlook 2013 for 7 countries, and the CIA World Factbook for 17 countries. For four countries (actually overseas departments of France), GDP per capita is from France's National Institute of Statistics and Economic Studies and is made relative to the U.S. GDP per capita using market exchange rates. GDP per capita for Âland Islands is from Statistics and Research Âland, and adjusted for purchasing power parity using Finland's PPP exchange rate from Penn World Table v. 8.0. Population data is from Penn World Table v. 8.0 (105 countries), the World Bank's World Development Indicators (21 countries), the CIA World Factbook (7 countries), and Statistics and Research Âland (for Âland Islands).

Table 1: Descriptive Statistics

	Mean	Median	Poorest Decile	Richest Decile
Establishment Size	12	9	6	19
GDP per capita (thousands)	18	13	1.2	55
Population (millions)	32	6	28	25

Notes: 'Poorest' and 'richest' refer to GDP per capita. Data from multiple sources, see text for details.

small countries with populations less than half of one million. In this case, the elasticity rises to 0.35. Each of these elasticities is remarkably robust to controlling for openness to trade and quality of institutions.[13] Recent models linking market size and markups predict that both GDP per capita and establishment size should increase with population, suggesting that the relationship illustrated in Figures 1 and 2 could be explained by differences in population size across countries.[14] But Figure 3 shows that establishment size is not systematically related to population.[15]

To confirm that the observed relationship between establishment size and GDP per capita is not being driven by how the establishment size data is constructed, we separately test the relationship between size and GDP for persons engaged per establishment, persons engaged per firm, employees per establishment, and employees per firm, using only the unadjusted source data for each country. The corresponding elasticities are all positive and of comparable magnitude: 0.38, 0.34, 0.32, and 0.28.[16]

We now compare the implications of our data relative to the existing work in the literature. A widely cited reference for the relationship between firm size and income is Alfaro et al.

[13] Our measure of openness to trade is from Penn World Table v. 8.0. Our measure of institutional quality is the Heritage Foundation's Index of Economic Freedom (2014).

[14] Melitz and Ottaviano (2008) and Desmet and Parente (2012), for example, each develop models in which larger populations can lead to both higher output per capita and larger establishments.

[15] The regression slope coefficient (standard error) in Figure 1 is 0.29 (0.04) and in Figure 2 is 0.35 (0.04). In Figure 3 the slope coefficient is insignificant -0.003 (0.03).

[16] The corresponding number of observations in each regression are 64, 48, 45, and 52.

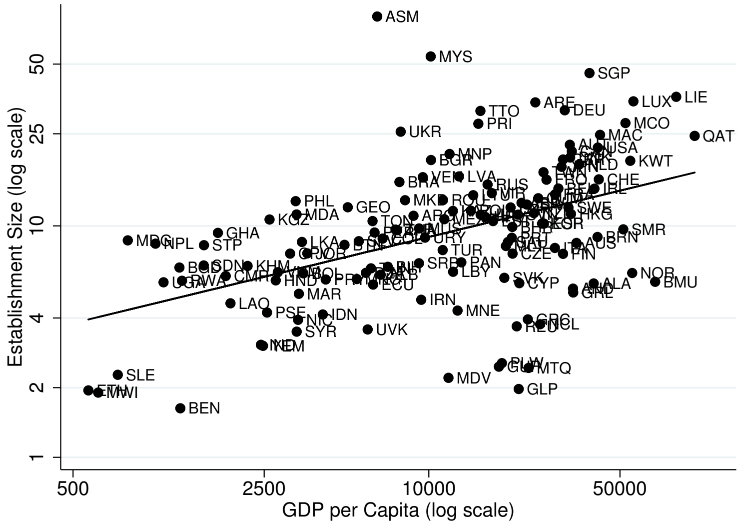

Figure 1: Establishment Size and GDP per Capita

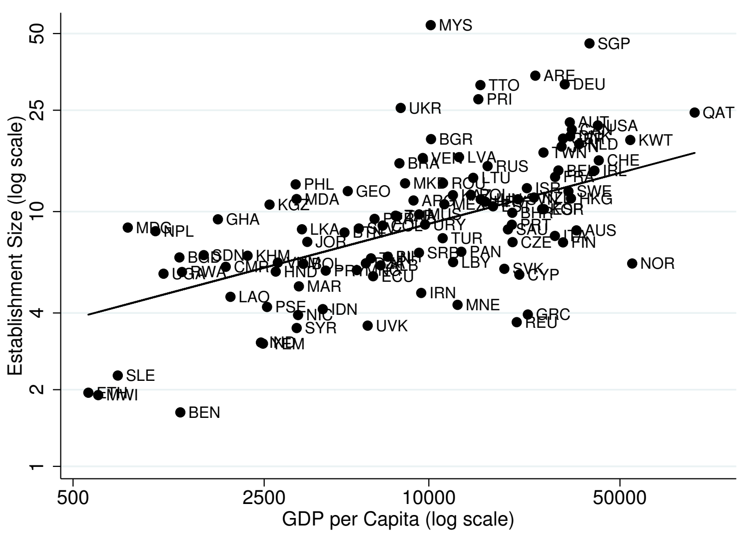

Figure 2: Establishment Size and GDP per Capita (small countries removed)

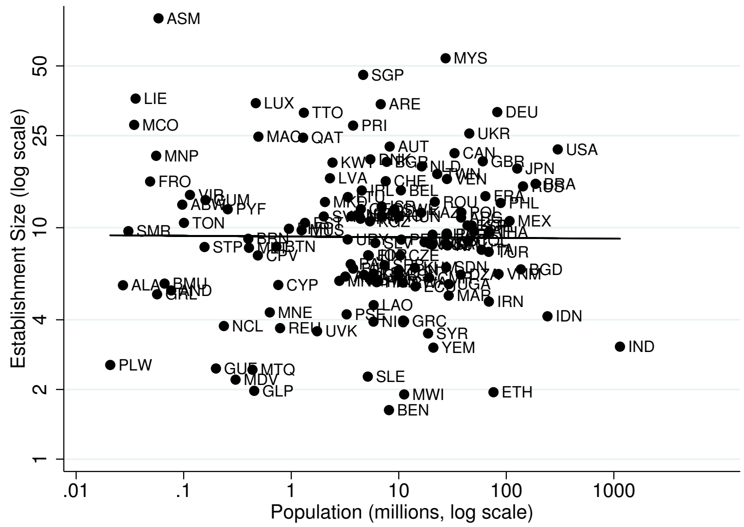

Figure 3: Establishment Size and Population

(2009). They use Dun & Bradstreet's WorldBase data (DB) to document a negative relationship between firm size and income per capita across 79 countries. More recently, Bollard et al. (2014) report the same negative relationship using data from the United Nations Industrial Development Organization's (UNIDO) Industrial Statistics Database for 72 countries. These observations are in direct contrast to those just documented from our data. They are also opposite to the relationship found for specific sectors such as agriculture where census data indicates much smaller farm size operation in poor countries relative to rich (see for instance Adamopoulos and Restuccia, 2014). To understand Alfaro et al., it useful to first emphasize that DB is comprised of business data aggregated from multiple sources that is typically used to provide credit and market-assessment services. A key issue is that DB has sparse coverage of small firms in poor countries relative to rich countries, with no attempt to make the data representative of all establishments. As a result, when calculating average establishment size in poor countries, the under-representation of small firms biases the average upwards. In a sense, Alfaro et al. are comparing average size across most establishments in rich countries with the average size of only large establishments in poor countries. The UNIDO data used by Bollard et al. similarly include countries with unbalanced populations of establishments, with some countries reporting data for all establishments and other countries reporting data only for larger establishments.[17] More importantly, our data contains information for 59 countries from Alfaro et al.'s sample and 59 countries from Bollard et al.'s sample, and the result of a positive relationship between establishment size and development is even stronger in these subsamples than for all 134 countries.

Poschke (2014) finds that firm and establishment size are strongly increasing in development, consistent with our evidence. Poschke uses two datasets, one from Global Entrepreneurship Monitor for small and medium firms in 47 countries, and one from Amadeus for large firms in 34 countries. Unlike Alfaro et al. (2009) and Bollard et al. (2014), the survey data used in Poschke is constructed in such a way as to be representative of all firms (within each size class) for each country. Although his sample of countries is smaller, Poschke is able to show that size is increasing in development across multiple sectors of the economy.

Comparing the results of our analysis with those of Alfaro et al. (2009), Bollard et al. (2014), and Poschke (2014) makes it clear that analyzing standardized, representative size data, especially with respect to the smallest establishments in poor countries, is crucial to obtaining clear evidence of the relationship between development and average employment size of establishments across countries.

3 The Model

Consider an economy where time is discrete and indexed by t. A representative final-good firm uses a variety of imperfectly substitutable inputs from intermediate-good firms to produce the final consumption good.[18] There is a stand-in household endowed with a continuum of members (of measure one), each supplying one unit of labor each period. There are a large number of potential intermediate firms who are free to enter, but must pay a fixed entry cost and make a

[17] For this reason, some of the countries used in Bollard et al. (2014) have been excluded from our dataset.

[18] Throughout we use 'firm' and 'establishment' interchangeably in reference to intermediate-good firms.

costly productivity-investment decision before producing. Firms face output distortions which may be correlated with firm-level productivity. Entrants take policy distortions into account when investing in productivity. We assume an exogenous probability of exit and, as a result, there is ongoing entry and exit in steady state. We study the decentralized equilibrium of the economy in which firms take the wage, the interest rate, and the size of the economy as given, and free entry ensures the value of entry is driven to zero. We then consider how the extent of correlated distortions affects the number of firms, investment, and aggregate output.[19] We begin by describing the environment in more detail.

3.1 Environment

The representative final-good firm produces output using a variety of inputs from intermediate-good firms according to the following production function;

$$Y = \left(\int_0^N y_i^{\frac{\sigma-1}{\sigma}} di \right)^{\frac{\sigma}{\sigma-1}},$$

where N is the number of intermediate-good firms, y_i the demand for input i, and σ the constant elasticity of substitution between varieties.

Each intermediate-good firm has access to the following production function;

$$y = sz\ell,$$

where sz is productivity and ℓ is labor. An entrant's realized z is drawn from a known exogenous distribution, while s is chosen by the entrant before realizing z. After paying an entry cost $c_e Y$, an entrant chooses s by incurring a cost equal to $c_S Y s^\theta$, where both $c_S > 0$ and $\theta > 1$ are exogenous and common to all firms.[20] At the end of each period, each intermediate producer

[19] We refer to the 'mass' of firms as the 'number' of firms for ease of exposition.

[20] Our specification of entry costs is consistent with Bollard et al. (2014), who argue using time-series data

faces an exogenous probability of exit equal to λ.

Output distortions are such that each firm retains a fraction $(1-\tau)$ of its output, and we assume τ depends on firm-level productivity as follows;

$$(1-\tau_i) = (s_i z_i)^{-\gamma},$$

where the parameter γ is the elasticity of a firm's distortion with respect to its productivity.

Given our assumptions, each firm will choose the same s in equilibrium, all entrants will choose to continue operating, and the distribution of productivities across firms will remain invariant. We abstract from the household's intertemporal consumption decision and simply assume an exogenous interest rate R.

3.2 Equilibrium

We focus on the steady-state decentralized equilibrium of the economy in which the distributions of prices and allocations are invariant. A *steady-state decentralized equilibrium* is defined as a wage rate w, distributions of firm-level productivities sz, intermediate-good prices P, output y, labor demand ℓ, and profits π, a number of firms N, and aggregate output Y, such that;

(i) given each P, the final-good firm demands intermediate-good inputs to maximize profits in each period,

(ii) given w, R, and Y, intermediate-good producers choose labor to maximize per-period profits,

(iii) given w, R, and Y, entrants choose productivity to maximize the expected present value of lifetime profits,

that entry costs should scale up with secular development. Note that if population were not normalized to one, we would need to make the entry and investment costs scale up with output per capita.

(*iv*) free entry ensures the expected present value of lifetime profits for an entrant is equal to the optimal productivity investment plus the entry cost,

(*v*) markets clear, i.e., the supply of labor (equal to one) is equal to the quantity of labor demanded by firms.

The final-good firm takes input prices as given and maximizes profits in each period, generating the following inverted demand function for each input i;

$$P_i = Y^{\frac{1}{\sigma}} y_i^{\frac{-1}{\sigma}}.$$

Profits in each period for an incumbent firm-i are therefore;

$$\pi_i = (1-\tau_i) Y^{\frac{1}{\sigma}} y_i^{\frac{\sigma-1}{\sigma}} - w\ell_i, \quad \text{where} \quad y_i = s_i z_i \ell_i.$$

Firms choose labor to maximize profits each period, generating the following demand for labor and optimal output;

$$\ell_i = \frac{(1-\tau_i)^\sigma Y (s_i z_i)^{\sigma-1}}{w^\sigma} \left(\frac{\sigma-1}{\sigma}\right)^\sigma,$$

$$y_i = \frac{(1-\tau_i)^\sigma Y (s_i z_i)^{\sigma}}{w^\sigma} \left(\frac{\sigma-1}{\sigma}\right)^\sigma.$$

Per-period profits for firm-i, given $s_i z_i$, are therefore;

$$\pi_i = \frac{(1-\tau_i)^\sigma Y (s_i z_i)^{\sigma-1} (\sigma-1)^{\sigma-1}}{w^{\sigma-1}\sigma^\sigma}. \tag{1}$$

Combining y_i above with the final-good production function results in the following expression;

$$w^\sigma = \left(\frac{\sigma-1}{\sigma}\right)^\sigma \left[\int_0^N (s_i z_i)^{\sigma-1}(1-\tau_i)^{\sigma-1} di\right]^{\frac{\sigma}{\sigma-1}}. \tag{2}$$

Labor-market clearing results in;

$$w^{\sigma} = Y\left(\frac{\sigma-1}{\sigma}\right)^{\sigma}\left[\int_0^N (s_i z_i)^{\sigma-1}(1-\tau_i)^{\sigma} di\right]. \tag{3}$$

Combining equations (2) and (3) and rearranging results in expressions for aggregate output and the wage rate;

$$Y = \left[\int_0^N (s_i z_i)^{\sigma-1}\left(\frac{1-\tau_i}{1-\overline{\tau}}\right)^{\sigma-1} di\right]^{\frac{1}{\sigma-1}}, \tag{4}$$

$$w = (1-\overline{\tau})\left(\frac{\sigma-1}{\sigma}\right)Y, \tag{5}$$

where $(1-\overline{\tau})$ is the weighted average of $(1-\tau_i)$ across all firms, weighted by each firm's share of aggregate output;

$$(1-\overline{\tau}) = \frac{1}{N}\int_0^N \frac{P_i y_i}{Y}(1-\tau_i) di.$$

We digress to more precisely explain the counterfactual experiment we are interested in. In Figure 4 the curve labeled 'low γ' represents the relationship between a firm's distortion τ_i and productivity $s_i z_i$ when γ is relatively low. In log scale, the slope of this curve is equal to γ, the elasticity of distortions with respect to productivity. To investigate the impact of more correlated distortions (a higher γ), we increase γ and then compare the two steady state equilibriums. While an increase in γ implies a pivoting of the curve in Figure 4, we must choose a point to pivot around. Following Hsieh and Klenow (2009), we choose $(1-\overline{\tau})^{-1}$ as the pivot. This means that as γ is increased in our counterfactual, $\overline{\tau}$ is kept constant. This allows us to focus on the effects of an increase in γ while abstracting from the (already well-studied) effects of a change in the average distortion.

Notice that aggregate output in equation (4) can be rewritten as;

$$Y = \left[\int_0^N \left(s_i z_i \frac{\overline{MRPL}}{MRPL_i}\right)^{\sigma-1} di\right]^{\frac{1}{\sigma-1}}, \tag{6}$$

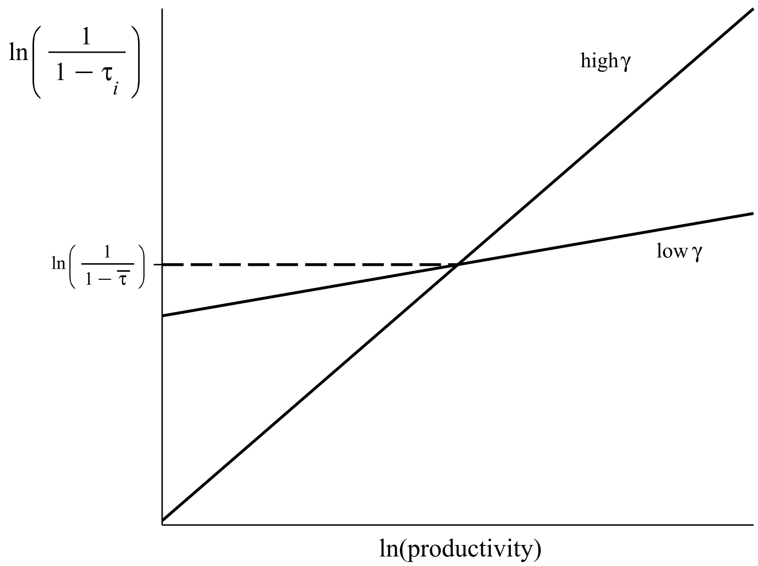

Figure 4: Firm-Level Distortions and Productivity

where a firm's revenue marginal product of labor and the average revenue marginal product of labor are defined as in Hsieh and Klenow (2009);

$$MRPL_i = \frac{P_i y_i}{\ell_i} \propto \frac{1}{(1-\tau_i)},$$

$$\overline{MRPL} = \left[\frac{1}{N}\int_0^N MRPL_i^{-1} \cdot \frac{P_i y_i}{Y} di\right]^{-1} \propto \frac{1}{(1-\overline{\tau})}.$$

Equation (6) makes clear that if firm-level productivity were exogenous, removing misallocation by setting each firm's $MRPL_i$ to $\overline{MRPL}$ (bringing γ to zero while maintaining $\overline{\tau}$) would have the same effect on aggregate output as in Hsieh and Klenow (2009), as long as the number of firms N is not affected. To see that N is indeed unaffected if productivity is exogenous, we use equations (1) and (2) to derive the expected per-period profits of an entrant;

$$E[\pi] = \frac{Y(\sigma-1)^{\sigma-1}}{w^{\sigma-1}\sigma^{\sigma}} \left(\frac{1}{N}\int_0^N (s_i z_i)^{\sigma-1}(1-\tau_i)^{\sigma} di\right) = \frac{Y(1-\overline{\tau})}{\sigma N}. \tag{7}$$

As long as the cost of entry scales up with aggregate output as is the case in our framework and $(1-\overline{\tau})$ is not affected by the removal of misallocation as we will assume in our counterfactual experiments, then equation (7) shows that the number of firms is independent of the extent of misallocation when productivity is exogenous.

To determine each firm's optimal productivity investment, we now take into account that $(1-\tau_i)$ is equal to $(s_i z_i)^{-\gamma}$. The value of entering for some firm i can be expressed as;

$$v_i = \frac{\mathbb{E}[\pi_i|s_i]}{1-\rho} - c_S Y s_i^\theta - c_e Y,$$

or

$$v_i = \frac{Y(\sigma-1)^{\sigma-1} s_i^{\sigma(1-\gamma)-1} \mathbb{E}[z_i^{\sigma(1-\gamma)-1}]}{(1-\rho) w^{\sigma-1} \sigma^\sigma} - c_S Y s_i^\theta - c_e Y, \tag{8}$$

where $\rho \equiv \frac{1-\lambda}{1+R}$, λ is the probability of firm death, and R is the real interest rate.

An entering firm will choose its productivity to maximize expected discounted profits. Given that all firms choose the same s in equilibrium, this results in the following condition;

$$c_S Y s^\theta = \frac{E[\pi]}{(1-\rho)} \frac{[\sigma(1-\gamma)-1]}{\theta}. \tag{9}$$

Free entry guarantees the value of entry will be zero in equilibrium, resulting in the following free-entry condition;

$$\frac{E[\pi]}{(1-\rho)} \frac{[\theta+1-\sigma(1-\gamma)]}{\theta} = c_e Y. \tag{10}$$

Using equations (7), (9), and (10), we can now solve for aggregate investment in productivity (as a share of output), firm-level productivity, and the number of firms in a stationary equilibrium;

$$\lambda N c_S s^\theta = \frac{\lambda[\sigma(1-\gamma)-1](1-\overline{\tau})}{\sigma\theta(1-\rho)} \tag{11}$$

$$s = \left(\frac{c_e[\sigma(1-\gamma)-1]}{c_S[\theta+1-\sigma(1-\gamma)]}\right)^{\frac{1}{\theta}} \tag{12}$$

$$N = \frac{[\theta+1-\sigma(1-\gamma)](1-\overline{\tau})}{c_e(1-\rho)\sigma\theta}. \tag{13}$$

Equations (11) through (13) show that productivity and investment are decreasing in the elasticity of distortions with respect to productivity (γ), whereas the number of firms is increasing in this elasticity. To gain intuition for these results, it is useful to first combine equations (7) and (9) to obtain an optimal investment condition expressing the optimal productivity s as a function of both γ and the number of firms N;

$$s = \left(\frac{[\sigma(1-\gamma)-1]}{c_S \sigma N (1-\rho)\theta} \right)^{\frac{1}{\theta}}. \tag{14}$$

We now use equations (7) and (8) to create an alternative free-entry condition in order to show the value of s necessary to ensure the value of entry is equal to zero, given N;

$$s = \left(\frac{1-\overline{\tau}}{c_S \sigma N (1-\rho)} - \frac{c_e}{c_S} \right)^{\frac{1}{\theta}}. \tag{15}$$

Both of the above conditions are represented in Figure 5, illustrating how s and N are obtained in equilibrium. As the elasticity of distortions with respect to productivity (γ) is increased, the incentive to invest in productivity is reduced, shifting the investment curve down. This reduction in the investment of entrants increases the value of entry, given N. Free entry thus encourages a movement down and to the right along the free entry curve until the increase in the number of firms brings the value of entry back down to zero.

Equations (11) and (13) also show both investment and the number of firms are decreasing in $\overline{\tau}$. The number of firms is also decreasing in the cost of entry c_e. These are common features of models with free entry, and reinforce the point that many of the policies often used to rationalize low productivity in poor countries should tend to *increase* the average size of firms.

Continue to consider our counterfactual exercise, wherein γ is increased while $\overline{\tau}$ is held constant. The total impact of these more correlated distortions on aggregate output can be decomposed into effects working through the investment channel, which is the focus in our paper, and the factor misallocation channel which is the focus of much of the earlier literature on misallocation

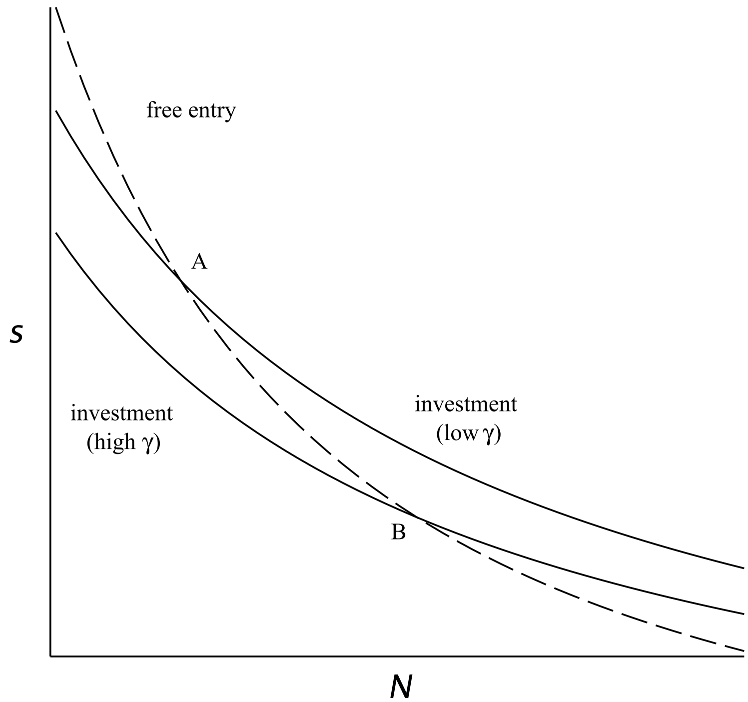

Figure 5: Firm-level Productivity (s) and the Number of Firms (N) in Equilibrium

such as Restuccia and Rogerson (2008) and Hsieh and Klenow (2009), as follows:

$$Y = \underbrace{s(\gamma) \cdot N(\gamma)^{\frac{1}{\sigma-1}}}_{\text{investment channel}} \cdot \underbrace{\left[\frac{1}{N} \int_0^N \left(z_i \cdot \frac{1-\tau_i}{1-\overline{\tau}} \right)^{\sigma-1} di \right]^{\frac{1}{\sigma-1}}}_{\text{factor misallocation channel}}. \tag{16}$$

As γ increases, τ_i rises more quickly with productivity, so productive firms hire more labor and unproductive firms hire less. The impact of this less efficient allocation of labor is captured by the factor misallocation channel above. But a higher γ also leads to a decrease in firm-level productivity s and an increase in the number of firms N. The impact of these changes is captured by the investment channel. Note that if greater misallocation simply implied more dispersion in random idiosyncratic distortions (uncorrelated with productivity), then equations (11) and (13) imply that output would not be affected through the investment channel. This reinforces the finding of Restuccia and Rogerson (2008) that simple random dispersion in idiosyncratic distortions cannot explain much variation in aggregate TFP, and that the strength of correlated distortions (in this paper, γ) is what generates the large potential impact from misallocation. In

Restuccia and Rogerson more correlated distortions cause a reallocation of resources, increasing the output of unproductive establishments marginally while disproportionately decreasing the output of productive establishments (while leaving the equilibrium number of establishments unchanged). By incorporating endogenous entry and investment, we show in this paper that more correlated distortions also reduce the marginal benefit of investing in productivity, thus reducing establishment-level productivity and decreasing average employment across all establishments.

4 Quantitative Analysis

In this section, we calibrate the model to U.S. data and show the quantitative implications for establishment size, productivity, and aggregate output of hypothetical variations in the degree of correlated distortions across countries. We then use establishment-level data to estimate empirically the extent of correlated distortions across countries and their implications for cross-country variations in establishment size, productivity, and output. We end the section with a discussion of these results for variations in the model setup as well as some robustness checks on parameter values.

4.1 Calibration

We calibrate the model to manufacturing data for the United States in order to quantify the cross-country effects of correlated distortions on average establishment size, productivity, and aggregate output. The effects of distortions working through the investment channel depend on three key parameters in our model:

- θ: the elasticity of the investment cost function with respect to establishment productivity,

- γ: the elasticity of distortions with respect to productivity,

- σ: the elasticity of substitution between varieties.

In order to keep a close tie with the literature for comparison, we follow Hsieh and Klenow (2009, 2014) in setting $\sigma = 3$. For U.S. manufacturing, Hsieh and Klenow (2014) report $\gamma_{US} = 0.09$. The productivity elasticity of investment, θ, plays a prominent role in determining the aggregate share of output invested in productivity, along with the exit rate λ, the real interest rate R, and the average level of distortions $\overline{\tau}$. Given values for λ, R, and $\overline{\tau}$, we choose a value for θ to match U.S. manufacturing's share of value added invested in intangible capital, equal to 0.192.[21] We set λ and R equal to 0.1 and 0.05, standard values in the literature. Our value for $\overline{\tau}$ is taken from the World Bank's Doing Business Surveys, which reports an average tax rate of 9 percent. Given each of these values, we use equation (11) to back out a value for θ of 1.91. We note that this value for θ is close to the value of 2.01 estimated using trade data in Rubini (2014).

The effect of distortions working through the factor misallocation channel depends on the parameters above, as well as on the distribution of z (the exogenous component of productivity). In the model, given our parsimonious representation of correlated distortions, there is a simple mapping between productivity z and employment, such that the demand for labor of establishment i relative to that of establishment j is;

$$\frac{\ell_i}{\ell_j} = \left(\frac{z_i}{z_j}\right)^{\sigma(1-\gamma)-1}.$$

Given values for σ and γ_{US}, we therefore use the above mapping to back out a distribution for z using data from the U.S. Census Bureau for the employment distribution of U.S. manufacturing

[21]McGrattan and Prescott (2010) estimate that 13.5 percent of total U.S. GDP is invested in technology and establishment-specific intangible capital. The evidence for manufacturing from other developed countries suggests a higher investment share in manufacturing than in the aggregate economy. For instance, Baldwin et al. (2009) report Canadian manufacturing's intangible investment as a share of value added is 1.42 times larger than the investment share of the entire economy. Assuming the same inflator for U.S. manufacturing implies an investment share of 19.2 percent which we use as our target.

establishments. Once we adjust the data to be representative of both paid and unpaid workers, we obtain a distribution of persons engaged per establishment ranging from 1 to 3,000 persons, and a distribution for z ranging from 1 to 102.[22]

Using the above distribution and our calibrated parameter values, we quantify how average establishment size, investment, and output per capita (TFP) changes with the extent of correlated distortions, i.e., when γ is increased above the U.S. level (keeping other parameters constant). We follow Hsieh and Klenow (2009) in maintaining a constant average distortion $\overline{\tau}$ as γ is increased. We report the results of this exercise in Table 2. The main finding is that the model implies large variations in average establishment size, productivity, and output per capita across economies with different correlated distortions.

Table 2: Model Results across Correlated Distortions γ

γ	Establishment Size	Establishment Productivity	Productivity Investment	Relative Output
0.09 (γ_{US})	22	1	0.19	1
0.15	11	0.66	0.17	0.91
0.2	7.8	0.52	0.16	0.83
0.3	4.9	0.36	0.12	0.65
0.4	3.6	0.26	0.09	0.48
0.5 (γ_{India})	2.8	0.18	0.06	0.31

Notes: Columns report equilibrium values of average establishment size ($1/N$), establishment productivity (s), aggregate productivity investment over output, and aggregate output (Y). Results in columns 2 and 4 are reported relative to the benchmark U.S. economy.

For instance, an economy with $\gamma = 0.4$ features an average establishment size that is 17 percent of that in the United States. This economy also features an establishment-level productivity that is 26 percent of the benchmark due to lower investment in productivity (only 47 percent

[22]We transform the employment distribution into a distribution of persons engaged by assuming non-employer establishments employ between 1 and 3 persons, while employer establishments with 1 to 4 employees are assumed to employ 3 to 5 persons. The employment data contain 10 employment ranges, and we assume establishment-level productivity is uniformly distributed within each range. The last range is open-ended (at least 1,000 employees), so we choose an upper bound of 3,000 to match an average employment size of 2,000 employees.

of that in the benchmark). As a result, output per capita is 48 percent of the benchmark economy. These are large differences in size and productivity compared to the findings in the broad literature on misallocation. The γ's in Table 2 are hypothetical, but the range is plausible. As a point of reference, consider that Hsieh and Klenow (2014) report $\gamma = 0.5$ for India. Given this value for γ, the model predicts an average establishment size of 2.8 workers, close to the value of 3.1 workers found in the data. The model also predicts India should have an aggregate output of about 31 percent of the U.S. level, generating a factor-difference in output about twice that found from factor misallocation only between the U.S. and India in Hsieh and Klenow (2009).

It is important to note that the effects of correlated distortions on establishment size and productivity work solely through the investment channel, while the impact on aggregate output works through both the investment and factor misallocation channels. In Table 3 we decompose this impact on aggregate output into the effects working through each channel. The effect of correlated distortions working through the investment channel are of a larger magnitude than that working through the factor misallocation channel, and the difference in relative magnitudes is increasing in γ. Note that the impact of distortions working through the factor misallocation channel for India is the same as that estimated for India by Hsieh and Klenow (2009), who use comprehensive micro data to back out distributions of distortions and productivity. We interpret this finding as suggestive that our parsimonious representation of idiosyncratic distortions through γ (the elasticity of distortions with respect to productivity) works extremely well as a summary measure of empirical distortions (actual wedges in the data).

We now compare our quantitative results to those in Hsieh and Klenow (2014). They model establishment-level investment over the life-cycle in the presence of correlated distortions and find that increasing γ from the U.S. level to that of India generates a reduction in average establishment size of only 12.5 percent.[23] This is in contrast to the 87 percent reduction in

[23]Hsieh and Klenow (2014) report that increasing γ generates an increase in the number of establishments of 14.3 percent (p. 1075). This implies a reduction in establishment size of 12.5 percent.

Table 3: DECOMPOSITION ACROSS CORRELATED DISTORTIONS γ

γ	Investment Channel	Factor Misallocation Channel	Total Impact
0.09 (γ_{US})	1	1	1
0.15	0.93	0.98	0.91
0.2	0.87	0.94	0.83
0.3	0.76	0.86	0.65
0.4	0.64	0.74	0.48
0.5 (γ_{India})	0.50	0.63	0.31

Notes: Columns 1 and 2 report the impact on aggregate output (Y) of distortions (higher γ's) working separately through the investment channel and the factor misallocation channel. Column 3 reports the total impact. All results are relative to the benchmark U.S. economy.

average establishment size implied by our results in Table 2. Since in our framework the average establishment size is just the inverse of the number of establishments, equation (13) above shows that the effect of γ on the number of establishments depends on two parameters, the elasticity of substitution between intermediate goods σ (for which we use the same value as Hsieh and Klenow) and the elasticity of investment with respect to productivity θ. We can therefore use this relationship to calculate the value of θ necessary to generate a reduction in average establishment size between the U.S. and India of 12.5 percent. The necessary θ is 10.3, much higher than our calibrated value of 1.91. To judge the reasonableness of these two values, note that equation (11) shows that aggregate investment in productivity also depends on θ. While our value of θ was obtained by matching U.S. manufacturing's investment share in intangible capital of 19 percent, a θ equal to 10.3 implies a much lower investment share of 3.6 percent. This is implausibly low as U.S. manufacturing's investment share in R&D (only one component of intangible capital) is 9.6 percent.[24]

[24] The U.S. manufacturing investment share in R&D is from UNESCO. In calculating the investment share implied by $\theta = 10.3$ we continue to assume $\overline{\tau} = 0.09$, as in our benchmark calibration. Alternatively, we can calculate the value of $\overline{\tau}$ required to match U.S. manufacturing's investment share, given $\theta = 10.3$. The required $\overline{\tau}$ is an equally implausible -3.9, implying an average *subsidy* to establishment-level output of 390 percent.

4.2 Correlated Distortions

The calibrated model shows how correlated distortions encourage smaller establishments, lower aggregate output, and lower investment in productivity. In this section, we provide systematic evidence that the productivity elasticity of distortions is indeed higher in poor countries. We then provide evidence consistent with the mechanism highlighted in Section 3, using cross-country R&D data to show that aggregate investment in R&D is increasing in development, average establishment size, and the extent of correlated distortions.

Our measure of correlated distortions is constructed using establishment-level data from the World Bank's Enterprise Surveys. Enterprise Surveys is an ongoing project of the World Bank to collect establishment-level data from mostly low and middle-income countries through face-to-face surveys. The dataset contains standardized information about sales, intermediate purchases, inputs, and a host of other variables for establishments in over 100 countries for at least one year since 2002. In each country, between 150 and more than 1000 establishments have been surveyed, and efforts have been made to make these samples representative of the population of establishments with at least five employees.[25] Importantly for our purposes, manufacturing establishments are classified into fifteen industries. From this dataset, we use observations containing values for industry classification, sales, number of employees, total wage bill, and purchases of materials and intermediate goods, for all countries which are also in our dataset (Section 2).

We back out our measure of establishment-level distortions and productivity for each establishment within a country-industry following Hsieh and Klenow (2009), except that we do not use capital data (more on this below). Abstracting from capital allows us to increase the number of usable countries substantially, as a large number of establishments in the Surveys do not

[25] Given the absence of very small establishments in the Enterprise Surveys data, we need to assume (as we do in Section 3) that the elasticity of distortions with respect to productivity is constant.

report capital. From Section 3, labor productivity for some establishment i is;

$$\frac{P_i y_i}{\ell_i} = \frac{w}{(1-\tau_i)}\left(\frac{\sigma}{\sigma-1}\right) \propto \frac{1}{(1-\tau_i)},$$

where $P_i y_i$ is an establishment's value added (sales minus intermediate inputs) and ℓ_i is employment.[26] As in Hsieh and Klenow, we remove the constant in the above expression by using labor productivity *relative to* the weighted average of labor productivity across all establishments within the same industry.[27] We infer an establishment's productivity sz_i by exploiting the following relationship;

$$sz_i = \frac{y_i}{\ell_i} \propto \frac{(P_i y_i)^{\frac{\sigma}{\sigma-1}}}{\ell_i}.$$

With our measures of distortions and productivity in hand, we then do a simple OLS regression of logged distortions on logged productivity to obtain each country's productivity elasticity of distortions.[28] Some countries have data for two or even three years, so we average elasticities over all years, weighting by the number of observations in each year. We obtain elasticities for 93 countries, 62 of which have establishment-size data.[29] Among these 62 countries, elasticities range from 0.22 to 0.74, averaging 0.52. Among all 93 countries the average elasticity remains a close 0.51. It is reassuring to note that our computed elasticity for India is 0.56, close to the value Hsieh and Klenow (2014) obtain using much more comprehensive micro data. To check the sensitivity of our measures to abstracting from capital, we also calculate elasticities using Hsieh and Klenow's (2009) TFPR and TFPQ as our measures of distortions and productivity.

[26]Following Hsieh and Klenow (2009), we use an establishment's total wage bill (including benefits) in our computations instead of employment in order to control for differences in human capital across establishments.

[27]More precisely, we measure the distortion faced by firm i as;

$$\frac{P_i y_i}{\ell_i} \cdot \sum_{i'=1}^{N}\left(\frac{P_{i'} y_{i'}}{\ell_{i'}}\right)^{-1} \cdot \frac{P_{i'} y_{i'}}{\sum_{i'=1}^{N} P_{i'} y_{i'}}.$$

Productivity sz_i is similarly measured relative to $\left(\sum_{i'=1}^{N}(sz_{i'})^{\sigma-1}\right)^{\frac{1}{\sigma-1}}$.

[28]Before doing the regressions, we first trim the 1 percent tails of both distortions and productivity for each country to remove outliers. We then recalculate the averages as above.

[29]We do not use countries with fewer than 100 observations. Over the 62 countries with size data, we use a total of 37,410 establishment-level observations in our regressions.

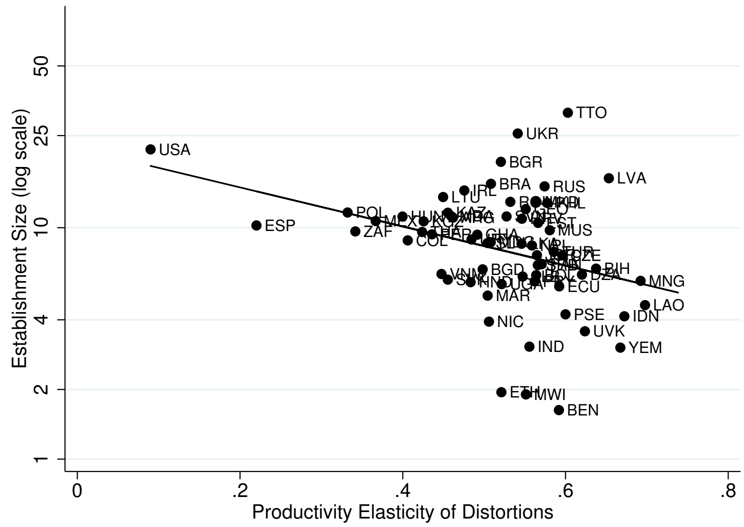

Figure 6: Establishment Size and Correlated Distortions

Among the 50 countries which satisfy the criteria above, the average elasticity is 0.56. If we recalculate these elasticities abstracting from capital data (but only using observations that report capital) we find the same average, and the correlation between the two measures is 0.89.[30]

Figures 6 and 7 show how average establishment size and GDP per capita are related to the productivity elasticity of distortions in 63 countries (the elasticity for the U.S., 0.09, is taken from Hsieh and Klenow, 2014).[31] The data show a clear link between the elasticity and both average size and GDP per capita, consistent with the model.

In the model developed in Section 3, the mechanism through which correlated distortions reduce establishment size is the disincentive to invest in productivity. As a consequence, the model also predicts the share of output invested in productivity should be lower in economies with high γ. Broad measures of investment in intangible capital have not yet been collected for a large number of countries, but R&D intensity (one significant component of intangible capital investment) should provide a fair proxy. Figure 8 shows how establishment size across countries

[30]This is consistent with Gal (2013, Table 9), who calculates both labor productivity and TFPR for firms in a handful of OECD countries and reports correlations between the two statistics ranging from 0.8 to 0.9.

[31]The regression coefficients (standard errors) in Figures 6 and 7 are -1.94 (0.46) and -3.01 (0.80).

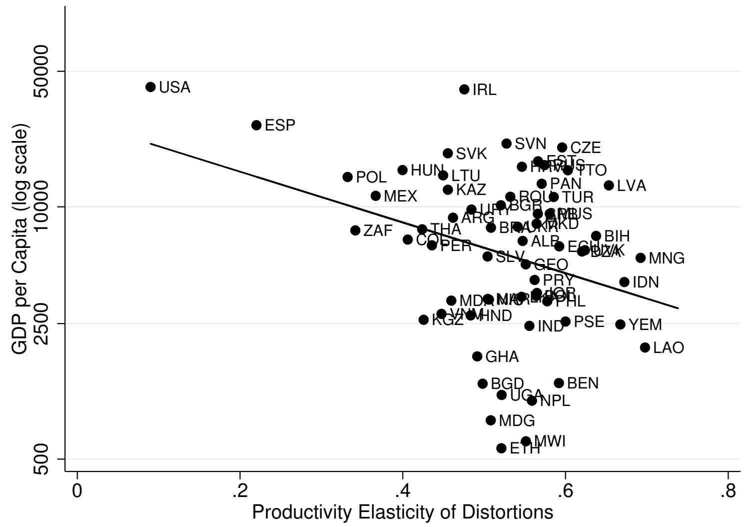

Figure 7: GDP per Capita and Correlated Distortions

varies with R&D intensity, while Figure 9 shows how R&D intensity is related to γ.[32] Again using India as a point of reference, the model predicts an investment share in India about 29 percent of the U.S. level. In the data, India's R&D intensity is exactly 29 percent of the U.S. level.

4.3 Discussion

We discuss our main results for reasonable extensions of the model and different values of key parameters.

Model Extensions In our baseline specification, the cost of entry and the investment cost of productivity are specified in units of aggregate output. Specifying both of these costs in units of labor dampens the effects of a higher γ very slightly. An economy with India's γ, for example, is predicted to have an establishment size of 2.9 workers per establishment, rather than the baseline prediction of 2.8. Extending the model to include capital and capital accumulation

[32]The regression coefficients (standard errors) in Figures 8 and 9 are 0.16 (0.04) and -4.23 (0.97). R&D data is taken from UNESCO, and is calculated as total investment in R&D as a share of GDP, relative to the U.S.

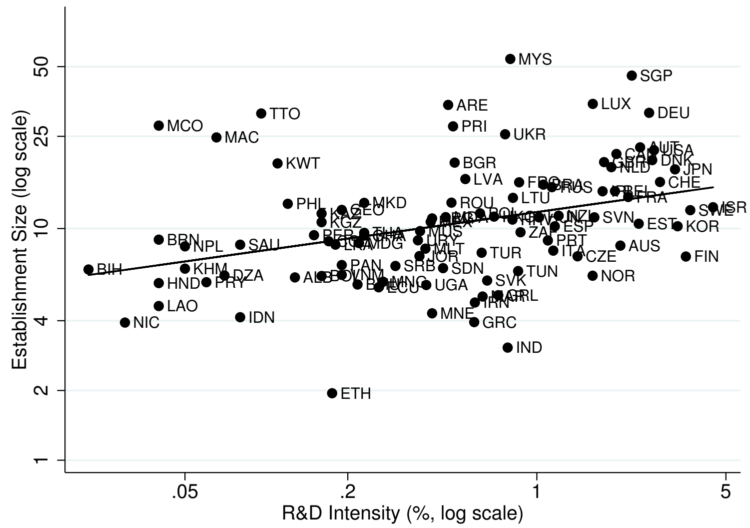

Figure 8: Establishment Size and R&D Intensity

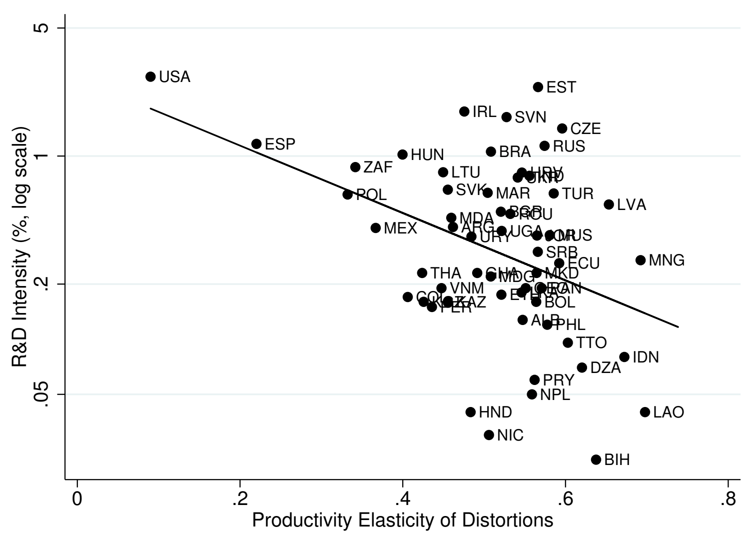

Figure 9: R&D Intensity and Correlated Distortions

does not change our results, as long as we interpret our baseline impact on aggregate output as an impact on TFP. The total impact on aggregate output would be magnified in the usual way through a change in the steady-state capital stock. Extending the model to allow entrants to learn the exogenous portion of their productivity (z) before investing would generate a richer relationship between γ and the productivity distribution across establishments, as the incentive for more productive firms to invest more than less productive firms would be dampened. We leave this as an interesting topic for future theoretical and empirical research.

Robustness on θ A critical parameter in determining the impact of correlated distortions on establishment size and output is the elasticity of investment in productivity θ. We explore variations in the cross country implications of the model for two alternative specifications of θ, 1.8 and 2.1. Recall that in the benchmark calibration $\theta = 1.91$ to match an aggregate investment share of 19.2 percent. Note that these values for θ could be obtained through our benchmark calibration strategy if we had used average distortions of $\overline{\tau} = 0.14$ (for $\theta = 1.8$) or $\overline{\tau} = 0$ (for $\theta = 2.1$).When $\theta = 1.8$, establishment size in the benchmark economy is 54 workers with an investment share of 20 percent, whereas when $\theta = 2.1$, establishment size is 12 workers with an investment share of 17 percent. We report the results of variations in correlated distortions on establishment size, productivity, investment, and aggregate output in Table 4. While the cross-country implications of the model are sensitive to the value of θ, for an empirically reasonable range, the model implies substantial negative effects of correlated distortions on establishment size and productivity.

Robustness on σ As in Hsieh and Klenow (2009), the impact of misallocation on aggregate output is increasing in σ, the elasticity of substitution between differentiated varieties. But assuming different values for σ is made complicated by the fact that σ determines the fraction of output allocated to entry costs, productivity investment, and taxes. In particular, a σ much higher than our benchmark of 3 cannot generate enough resources to cover investment (19.2

Table 4: Model Results across Correlated Distortions γ

γ	Establishment Size	Establishment Productivity	Productivity Investment	Relative Output
		$\theta = 1.8$		
0.09 (γ_{US})	54	1	0.20	1
0.15	14	0.46	0.18	0.85
0.2	6.8	0.34	0.17	0.76
0.3	4.5	0.22	0.13	0.59
0.4	3.4	0.15	0.09	0.42
0.5 (γ_{India})	2.9	0.10	0.06	0.27
		$\theta = 2.1$		
0.09 (γ_{US})	12	1	0.17	1
0.15	8.0	0.79	0.16	0.93
0.2	6.3	0.67	0.14	0.87
0.3	4.4	0.50	0.11	0.71
0.4	3.4	0.38	0.08	0.53
0.5 (γ_{India})	2.7	0.28	0.05	0.36

Notes: Columns report equilibrium values of average establishment size ($1/N$), establishment productivity (s), aggregate productivity investment over output, and aggregate output (Y). Results in columns 2 and 4 are reported relative to an economy with $\gamma = \gamma_{US}$.

percent of aggregate output) and taxes (9 percent). However, McGrattan and Prescott (2010) estimate that investment for the entire U.S. economy is a lower 13.5 percent. We therefore recalibrate the model to match an investment share of 0.135 using a higher $\sigma = 5$, and interpret our results as the effects of correlated distortions on the entire economy.[33] Our recalibrated value for θ is 3.68. In addition, assuming a higher value for σ generally increases the estimates of γ we obtain in Section 4.2, which will tend to increase the implied impact of observed misallocation. We therefore recalculate γ_{India} using $\sigma = 5$ to get $\gamma_{India} = 0.77$. In Table 5 we report the estimated impact of misallocation in India relative to the United States with $\sigma = 3$ (our benchmark) and with $\sigma = 5$. The net result is that the effect of misallocation in India on each variables is magnified when σ is increased.

[33] Here we assume an average distortion of zero.

Table 5: Model Results for Different σ's

σ, θ	Establishment Size	Establishment Productivity	Productivity Investment	Relative Output
$\sigma = 3$ $\theta = 1.91$	0.13	0.18	0.29	0.31
$\sigma = 5$ $\theta = 3.68$	0.04	0.17	0.04	0.26

Notes: Columns report equilibrium values of average establishment size ($1/N$), establishment productivity (s), aggregate productivity investment over output, and aggregate output (Y). Results are reported relative to an economy with $\gamma = \gamma_{US}$ and $size = size_{US}$, with θ and γ_{India} recalculated for each value of σ (see text for details).

5 Conclusion

Using a unique dataset of manufacturing establishments we construct from hundreds of sources, we have documented a strong positive association between average establishment size and GDP per capita. The cross-country income elasticity of establishment size is 0.29 in our sample of 134 countries. We considered an otherwise standard model of heterogenous establishments with endogenous entry and investment in establishment productivity. We showed that a reasonably calibrated version of the model generates substantial differences in establishment size and productivity across countries. These differences arise in the presence of correlated distortions which we construct and document across countries. Overall, the analysis in this paper puts us closer to understanding the patterns in operational scale and productivity observed across countries and over time.

Our analysis has abstracted from many factors which may be worth exploring further. For example, we have abstracted from different forms of entry and operation costs that seem to hinder the operation of firms in many poor countries. We have also abstracted from investment over the life-cycle of establishments which would generate a richer relationship between correlated distortions and the establishment-level productivity distribution. We leave a detailed exploration of these factors for future research.

A Establishment Size Data

We describe in more detail how we construct the establishment size data. Our standardized definition of establishment size is the number of persons engaged per manufacturing establishment. Persons engaged is defined as the average number of persons working for an establishment, both paid and unpaid. A manufacturing establishment is defined as a physical location where the primary activity is manufacturing. Households are counted as an establishment only if signs are posted on the property indicating commercial activity. Not all countries report persons engaged or the number of establishments, so we also use data on the number of paid employees, the number of full-time equivalent employees, and the number of firms (collections of one or more establishments under common ownership).

The source data for each country is from economic censuses, as well as surveys which use comprehensive business registries to create sampling frames.[34] We use all publicly available data for the years 2000 through 2012.[35] In an effort to maintain consistency across countries, we do not use data unless efforts were made by a statistical agency to make the data representative of an economy's entire population of manufacturing establishments. We exclude any data collected without accounting for small establishments, except in cases where only establishments without paid employees are excluded. In the later case, we use U.S. data to adjust measured establishment size (this is the case for eight countries). Further, we include data for any country that excludes establishments with low revenue, as long as the revenue threshold is lower than the country's GDP per capita (this is the case for four countries). Two countries (Algeria and Honduras) do not report employment, but do report the distribution of establishments across multiple employment tranches. In these two cases we estimate total employment by using an average employment within each tranche consistent with data in comparable countries.[36] We

[34]For some countries data is from EUROSTAT or OECD's Structural Business Statistics, but we check each country's methodology to confirm the consistency of definitions.

[35]In some cases countries have published only press releases or bulletins describing the census data. We include these countries when the data meets our criteria.

[36]We assume average employment within a tranche to be one third of the distance from the lower to the upper threshold. For the last open-ended tranche (for example, 200 or more employees) we assume an average

are left with 134 countries with useable data for at least one year, with an average of six years per country.[37] Table 6 reports the total number of countries reporting each variable for at least one year, as well as the total number of poor countries and the total number of rich countries (defined as having GDP per capita below and above the median) doing the same.

Table 6: Sample of Countries

Variable	Total Number of Countries	Number of Poor Countries	Number of Rich Countries
persons engaged	101	54	47
employees	86	34	52
engaged and employees	53	21	32
full-time equivalents	25	2	23
establishments	83	45	38
firms	67	26	41
establishments and firms	16	4	12

Note: 'Poor' and 'Rich' refer to countries with GDP per capita below and above the median. Data from multiple sources, see text for details.

We construct our standardized measure of establishment size (persons engaged per establishment) in the following way. First, we regress persons engaged on employees and full-time equivalent employees, as well as on employees and full-time equivalents separately. Second, country-years which report employees or full-time equivalents (or both) but lack measures of persons engaged are then assigned predicted values using the estimated coefficients from the above regressions. Third, predicted values for persons engaged per establishment are then assigned to country-years which report only firm-level data using the estimated coefficient from a regression of persons engaged per establishment on persons engaged per firm. Fourth, to standardize persons engaged per establishment in country-years which exclude non-employer establishments (this is the case for eight countries), we multiply these values by a factor equal to the average ratio of persons engaged per establishment to persons engaged per establishment with paid employees across all years in the U.S. (this ratio is 0.51). The same method is used to

employment equal to twice the lower threshold.

[37]Although size data is also available for Norfolk Island, it has been dropped for lack of any reliable measure of GDP per capita.

standardize data for five countries which report statistics for a combination of manufacturing, extraction, and energy (this ratio is 1.14). The results of the four regressions described above are;

- persons engaged = 1.44 · employees − 0.40 · full-time equivalents
- persons engaged = 1.07 · employees
- persons engaged = 1.12 · full-time equivalents
- persons engaged per establishment = 0.89 · persons engaged per firm

In our final dataset, persons engaged per establishment is averaged over all years for each of the 134 countries.

Table 7 lists each country in the final dataset, the number of years for which data is available, and the sources from which data has been collected.

Table 7: List of Countries and Sources

Country	Code	Years	Sources
Åland Islands	ALA	9	Statistics and Research Åland: Statistical Yearbooks of Åland 2006-2010 and 2013, and www.asub.ax
Albania	ALB	8	Instituti i Statistikave: www.instat.gov.al/en/figures/statistical-databases.aspx
Algeria	DZA	1	Office National des Statistiques, Alger: Premier recensement économique -2011- Résultats définitifs
American Samoa	ASM	2	U.S. Census Bureau: 2002, 2007 County Business Patterns, and 2002, 2007 Nonemployer Statistics
Andorra	AND	12	Departament d'Estadística: 2010 Statistical Yearbook, and www.estadistica.ad
Argentina	ARG	1	Instituto Nacional de Estadística y Censos: 2005 Economic Census
Aruba	ABW	1	Central Bureau of Statistics: Business Count 2003
Australia	AUS	5	Australian Bureau of Statistics: Counts of Australian Businesses 2003-2007, Labour Force Surveys (Quarterly)
Austria	AUT	12	Statistik Austria: statcube.at, and OECD's SDBS Structural Business Statistics
Bahrain	BHR	2	Kingdom of Bahrain Central Informatics Organization: Population, Housing, Buildings, Establishments and Agriculture Census
Bangladesh	BGD	1	Bangladesh Bureau of Statistics: Economic Census 2001 & 2003
Belgium	BEL	11	Eurostat, and OECD's SDBS Structural Business Statistics
Benin	BEN	1	Institut National de la Statistique et de l'Analyse Economique: General Census of Companies, and Les Entreprises Artisanales au Benin
Bermuda	BMU	11	Department of Statistics: www.govsubportal.com
Bhutan	BTN	4	National Statistics Bureau: Statistical Yearbooks 2010-2013
Bolivia	BOL	1	Instituto Nacional de Estadística: Structural Statistics of the Manufacturing Industry, Trade and Services - 2010, and Results of the Quarterly Survey of Micro and Small Business 2010
Bosnia and Herzegovina	BIH	8	Institute for Statistics of FB&H: Statistical Yearbooks 2008-2013
Brazil	BRA	13	Brazilian Institute of Geography and Statistics: Cadastro Central de Empresas
Brunei	BRN	1	Department of Economic Planning and Development: Brunei Darussalam Statistical Yearbook 2010
Bulgaria	BGR	12	Eurostat
Cambodia	KHM	2	National Institute of Statistics: Economic Census 2011, and Establishment Listing 2009
Cameroon	CMR	1	Institut National de la Statistique du Cameroun: Recensement Général des Entreprises 2009
Canada	CAN	7	Statistics Canada: CANSIM
Cape Verde	CPV	4	Instituto Nacional de Estatística: Business Census 2007, and Annual Business Surveys 2008-2009
Columbia	COL	1	Departamento Administrativo Nacional de Estadística: Encuesta Annual Manufacturera, and www.dane.gov.co
Croatia	CRV	4	Eurostat

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Country	Code	Years	Sources
Cyprus	CYP	12	Eurostat
Czech Republic	CZE	10	Eurostat, and OECD's SDBS Structural Business Statistics
Denmark	DNK	12	Eurostat, and OECD's SDBS Structural Business Statistics
Ecuador	ECU	1	Instituto Nacional Estadística y Censos: National Economic Census 2010
El Salvador	SLV	1	Ministerio de Economica: Tomo I de los VII Censos Económicos Nacionales 2005
Estonia	EST	1	Statistics Estonia: Statistical Yearbooks 2011-2013, and pub.stat.ee
Ethiopia	ETH	1	Central Statistical Agency: Report on Small Scale Manufacturing Industries Survey 2005/6, Report on Large and Medium Scale Manufacturing and Electricity Industries Survey 2005/6, and Labour Force Survey 2005
Faroe Islands	FRO	12	Statistics Faroe Islands: www.hagstova.fo
Finland	FIN	1	Statistics Finland: Labour Force Survey 2013, and www.stat.fi
France	FRA	9	Institut National de la Statistique et des Études Économiques: Tableaux de l'Économie Française - Édition 2005-6, 2010-2014, L'industrie en France - édition 2007, 2008, and www.insee.fr
French Guiana	GUF	1	Institut national de la statistique et des études économiques: Caractéristiques des entreprises et établissements
French Polynesia	PYF	13	Institut de la Statistique de la Polynésie Française: www.ispf.pf
FYR Macedonia	FYR	5	State Statistical Office: www.stat.gov.mk
Georgia	GEO	11	National Statistics Office of Georgia: Statistical Yearbooks 2009-2013, and www.geostat.ge
Germany	DEU	12	Eurostat, and OECD's SDBS Structural Business Statistics
Ghana	GHA	1	Ghana Statistical Service: National Industrial Census 2003
Greece	GRC	6	Eurostat, and OECD's SDBS Structural Business Statistics
Greenland	GRL	5	Statistics Greenland: bank.stat.gl
Guadeloupe	GLP	1	Institut national de la statistique et des études économiques: Caractéristiques des entreprises et établissements
Guam	GUM	7	U.S. Census Bureau: 2008-2011 County Business Patterns, and 2002, 2007, 2012 Economic Census of Island Areas
Honduras	HND	1	Instituto Nacional de Estadística y Censos: Directorio de Establecimientos Económicos
Hong Kong	HKG	13	Census and Statistics Department: Annual Survey of Industrial Production, and www.statistics.gov.hk
Hungary	HUN	11	Eurostat, and OECD's SDBS Structural Business Statistics
India	IND	1	Central Statistics Office: 2005 Economic Census
Indonesia	IDN	3	Statistics Indonesia: Statistical Yearbook 2013
Iran	IRN	1	Statistical Centre of Iran: Statistical Yearbook 1382
Israel	ISR	9	Central Bureau of Statistics: www1.cbs.gov.il, Eurostat, and OECD's SDBS Structural Business Statistics
Italy	ITA	12	Eurostat, and OECD's SDBS Structural Business Statistics
Japan	JPN	3	Statistics Japan: Establishment and Enterprise Censuses 2001, 2004, 2006

Table 7: List of Countries and Sources

Country	Code	Years	Sources
Jordan	JOR	8	Department of Statistics: www.dos.gov.jo
Kazakhstan	KAZ	1	Committee on Statistics: www.stat.gov.kz
Korea	KOR	9	Statistics Korea: Censuses on Establishments 2007, 2009, 2011, 2012
Kosovo	UVK	6	Statistical Agency of Kosovo: Statistical Register of Business
Kuwait	KWT	10	Central Statistical Bureau: Annual Surveys of Establishments 2002-2011
Kyrgyzstan	KGZ	1	National Statistical Committee of Kyrgyz Republic: stat.kg
Laos	LAO	1	Lao Statistics Bureau: Economic Census 2006
Latvia	LVA	10	Central Statistical Bureau of Latvia: www.csb.gov.lv, and Eurostat
Libya	LBY	2	Bureau of Statistics and Census Libya: bsc.ly
Liechtenstein	LIE	6	Statistical Office: Statistical Yearbooks 2007/2008, 2009-2012
Lithuania	LTU	7	Eurostat
Luxembourg	LUX	12	Eurostat
Macau	MAC	13	Statistics and Census Service: www.dsec.gov.mo
Madagascar	MDG	1	Institut National de la Statistique: Rapport de l'enquete sur les Entreprises a Madagascar
Malawi	MWI	6	National Statistical Office: www.nsomalawi.mw
Malaysia	MYS	6	Department of Statistics Malaysia: Statistics Yearbooks 2007-2012
Maldives	MDV	1	Department of National Planning: Economic Survey 2007/2008
Malta	MLT	7	Eurostat
Martinique	MTQ	1	Institut national de la statistique et des études économiques: Caractéristiques des entreprises et établissements
Mauritius	MUS	2	Statistics Mauritius: Censuses of Economic Activity 2002, 2007, Phases I and II
Mexico	MEX	2	Instituto Nacional de Estadstica y Geografía: Censos Economicos 2004, 2009
Moldova	MDA	8	Statistica Moldovei: www.statistica.md
Monaco	MCO	13	Monaco Statistics: Observatoire de l'Economie 2012, 2013
Mongolia	MNG	2	National Statistical Office of Mongolia: Monthly Bulletins of Statistics 2011, 2012
Montenegro	MNE	3	Statistical Office of Montenegro: www.monstat.org
Morocco	MAR	1	Haut-Commissariat au Plan du Maroc: 2001-2 Economic Census
Nepal	NPL	1	Central Bureau of Statistics: Census of Manufacturing Establishments 2006/7, Survey of Small Manufacturing 2008/9
Netherlands	NLD	11	Eurostat, Statistics Netherlands: Statistical Yearbooks 2004-2013
New Caledonia	NCL	13	Institut de la Statistique et des Etudes Economique: www.isee.nc
New Zealand	NZL	13	Statistics New Zealand: www.stats.govt.nz
Nicaragua	NIC	1	Instituto Nacional de Información de Desarrollo: Urban Economic Census
Norfolk Island	NFK	1	Australian Business Statistics: www.ausstats.abs.gov.au
Northern Mariana Islands	MNP	6	U.S. Census Bureau: 2008-2011 County Business Patterns, and 2007, 2012 Economic Census of Island Areas
Norway	NOR	8	Eurostat, and OECD's SDBS Structural Business Statistics

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Country	Code	Years	Sources
Palau	PLW	1	Office of Planning and Statistics: 2012 - 2nd, 3rd Quarters Economic Indicators
Palestinian Territories	PSE	7	Palestinian Central Bureau of Statistics: Establishment Censuses 2004, 2007, 2012, and Comparison Study on Industrial Activities 1999-2004
Panama	PAN	1	Instituto Nacional de Estadística y Censo: Preliminary Results of Economic Census 2012
Paraguay	PRY	1	Direccin General de Estadística, Encuestas y Censos: National Economic Census 2011
Peru	PER	1	Instituto Nacional de Estadística e Informática: IV Censo National Economico 2008
Philippines	PHL	2	National Statistics Office: NSO's 2012 List of Establishments, and 2003 Annual Survey of Philippine Business and Industry (ASPBI)
Poland	POL	12	Central Statistical Office of Poland: Statistical Yearbook 2011, 2012, Eurostat, and OECD's SDBS Structural Business Statistics
Portugal	PRT	11	Eurostat, and OECD's SDBS Structural Business Statistics
Puerto Rico	PRI	7	U.S. Census Bureau: 2006-2011 County Business Patterns, and 2002 Economic Census of Island Areas
Qatar	QAT	3	Ministry of Development Planning and Statistics: Establishment Censuses 2004, 2008, 2010
Réunion	REU	3	Institut national de la statistique et des études économiques: Caractéristiques des entreprises et établissements
Romania	ROU	6	National Institute of Statistics: Statistical Yearbooks 2006-2012
Russia	RUS	3	Federal State Statistics Service: Industry of Russia 2008, 2009, 2011, and Small and Medium Businesses in Russia 2008, 2009, 2011
Rwanda	RWA	1	National Institute of Statistics of Rwanda: Establishment Census - 2011
San Marino	SMR	8	Ufficio Informatica, Tecnologia, Dati e Statistica: www.statistica.sm
São Tomé and Príncipe	STP	2	Instituto Nacional de Estatísticas de São Tomé e Príncipe: Business Statistics 2006, 2007
Saudi Arabia	SAU	1	Central Department of Statistics and Information: 2010 Economic Census
Serbia	SRB	3	Republika Srpska Institute of Statistics: Statistical Yearbook of Republika Srpska 2011, 2012, 2013
Sierra Leone	SLE	1	Statistics Sierra Leone: Report of the Census of Business Establishments 2005
Singapore	SGP	10	Department of Statistics Singapore: Census of Manufacturing Activities 2012
Slovak Republic	SVK	2	Eurostat
Slovenia	SVN	12	Eurostat, and OECD's SDBS Structural Business Statistics
South Africa	ZAF	12	Statistics South Africa: Annual Financial Statistics 2010, 2012, and Survey of Employers and the Self-Employed 2013
Spain	ESP	12	Eurostat, and OECD's SDBS Structural Business Statistics

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Country	Code	Years	Sources
Sri Lanka	LKA	1	Department of Census and Statistics - Sri Lanka: Census of Industry 2003/4
Sudan	SDN	1	Central Bureau of Statistics: Statistical Year Book for the Year 2009
Sweden	SWE	12	Eurostat, and OECD's SDBS Structural Business Statistics
Switzerland	CHE	3	Swiss Statistics: www.bfs.admin.ch/bfs/portal/en/index.html
Syria	SYR	4	Central Bureau of Statistics: www.cbssyr.sy
Taiwan	TWN	3	National Statistics: Industry, Commerce and Service Censuses 2001, 2006, 2011
Thailand	THA	2	National Statistical Office: Industrial Censuses 2007, 2012
Tonga	TON	7	Tonga Department of Statistics: Manufacturing Output, Employment and Wages/Salaries 2000-2003, 2001-2005, 2002-2006
Trinidad and Tobago	TTO	7	Central Statistical Office: Business Establishments in T & T by Industry Economic Activity 2005-2007
Tunisia	TUN	12	Institut National de la Statistique: Statistiques Issues du Répertoire des Entreprises
Turkey	TUR	8	Eurostat, and OECD's SDBS Structural Business Statistics
Uganda	UGA	2	Uganda Bureau of Statistics: Report on the Census of Business Establishments 2010/2011, and Business Register 2001/02
Ukraine	UKR	3	State Statistics Service of Ukraine: www.ukrstat.gov.ua
United Arab Emirates	ARE	1	National Bureau of Statistics: www.uaestatistics.gov.ae
United Kingdom	GBR	12	Eurostat, and OECD's SDBS Structural Business Statistics
United States	USA	11	U.S. Census Bureau: 2002-2011 County Business Patterns, and 2002-2011 Nonemployer Statistics
Uruguay	URY	9	Instituto Nacional de Estadística: Anuario Estadístico 2000-2012
U.S. Virgin Islands	VIR	2	U.S. Census Bureau: County Business Patterns, and 2002, 2012 Economic Census of Island Areas
Venezuela	VEN	1	Instituto Nacional de Estadística: IV Censo Económico
Vietnam	VNM	3	General Statistics Office: Establishment Censuses 2002, 2007, and 2012
Yemen	YEM	2	Central Statistical Organization: Results of Economic Surveys 2005-2006

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