University of Toronto
Department of Economics

Working Paper 612

On Average Establishment Size across Sectors and Countries

By Pedro Bento and Diego Restuccia

August 18, 2018

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Pedro Bento
Texas A&M University[*]

Diego Restuccia
University of Toronto
and NBER[**]

August 2018

Abstract

We construct a new dataset for the average employment size of establishments across sectors and countries from hundreds of sources. Establishments are larger in manufacturing than in services, and in each sector they are larger in richer countries. The cross-country income elasticity of establishment size is remarkably similar across sectors, about 0.3. We discuss these facts in light of several prominent theories of development such as entry costs and misallocation. We then quantify the sectoral and aggregate impact of entry costs and misallocation in an otherwise standard two-sector model of structural transformation with endogenous firm entry and firm-level productivity. We find that observed measures of misallocation account for the entire range of establishment-size differences across sectors and countries and almost 50 percent of the difference in non-agricultural GDP per capita between rich and poor countries.

Keywords: establishment size, manufacturing, services, distortions, misallocation, productivity.
JEL codes: O1, O4, O5, E02, E1.

[†]For helpful comments we thank Alvaro Garcia Marin and seminar participants at the Banco Central de Chile and National University of Singapore. All errors are our own. Restuccia gratefully acknowledges the support from the Social Sciences and Humanities Research Council of Canada and the Canada Research Chairs program.

[*]Department of Economics, Texas A&M University, 3056 Allen Building, 4228 TAMU, College Station, TX 77843, USA. E-mail: pbento@tamu.edu.

[**]Department of Economics, University of Toronto, 150 St. George Street, Toronto, ON M5S 3G7, Canada. E-mail: diego.restuccia@utoronto.ca.

1 Introduction

We construct a newly-assembled dataset for the average employment size of service-sector establishments for up to nine service industries across a large sample of countries. We use census or representative survey data from hundreds of sources. We combine this data for the service sector with that of the manufacturing sector from Bento and Restuccia (2017) to provide a more comprehensive view of establishment size in the non-agricultural sector across countries. We show that average establishment size is generally larger in manufacturing than in services, and in each sector is strongly positively related with the level of development. In particular, the cross-country income elasticity of establishment size is positive and remarkably similar across sectors of around 0.3. A critical element in the construction of our dataset for international comparisons is the inclusion of *all* establishments regardless of whether they are registered or informal and have paid employees or are self-account businesses as there is systematic variation in these categorizations across countries that can bias the relationship between establishment size and development.

Average establishment size is an endogenous outcome in many prevailing theories of development and aggregate total factor productivity (TFP). Our dataset can be used to calibrate quantitative models and to test alternative theories that have heretofore been observationally equivalent with respect to available data. As a first step towards this end, we document the empirical cross-country relationships between our measures of average establishment size and several country- and sector-specific variables, such as measures of sectoral shares, openness to trade, external finance, firing costs, and misallocation; and then discuss the resulting patterns in the context of the relevant theories. The empirical finding that is most closely aligned with current theory is the negative relationship between average establishment size and the extent of misallocation across countries in each sector. The measure of misallocation we focus on is the productivity elasticity of distortions across establishments (or correlated distortions for short), which we calculate using micro data from the World Bank's Enterprise Surveys for a large number of countries. Models with endogenous entry and investment in establishment-level productivity are most closely aligned with the evidence as in these frameworks correlated distortions reduce aggregate productivity by misallocating factors across heterogeneous establishments, reducing investment in productivity, and reducing average establishment size (Hsieh and Klenow, 2014; Bento and Restuccia, 2017).

In light of this empirical evidence and because our data indicates that misallocation around the world is characterized by systematically larger productivity elasticities of distortions in both sectors in poorer countries, we develop a two-sector model of non-agriculture featuring heterogeneous establishments making entry and productivity decisions. We focus on productivity investment by entering establishments, abstracting from investment after entry.[1] The model builds on the frameworks of Hopenhayn (1992) and Restuccia and Rogerson (2008). Upon entering the market, establishments pay a cost to increase their productivity. After this investment, an idiosyncratic productivity is realized. Establishments face policy distortions that are related to their overall productivity and hence entering establishments consider these distortions when making productivity investments. Consumers have preferences over consumption of manufacturing goods and services, and relative productivities are key determinants of sectoral allocations.

We calibrate a benchmark economy with no distortions to U.S. data and study how variations in the productivity elasticity of distortions affect sectoral establishment size and productivity as well as aggregate outcomes. Our analysis shows that empirically-reasonable variations in the productivity elasticity of distortions across countries in each sector generate substantial differences in average establishment size and productivity in each sector as well as structural change and aggregate output across economies. For instance, when we increase the productivity elasticity of distortions in each sector from zero in the U.S. benchmark economy to 0.7 (a level observed for many developing countries in our data), average establishment size drops from 22 to 8 persons engaged in the manufacturing sector and from 4.8 to 1.7 persons engaged in the

[1] Hsieh and Klenow (2014) and Bento and Restuccia (2017) find that incorporating life-cycle productivity investment does little to amplify the effect of policy distortions on aggregate productivity, beyond the impact of factor misallocation.

service sector, a reduction in size that is consistent with and close in magnitude to the evidence we document across countries. The increase in distortions also reduces sector productivity by 57 percent, only half of which is driven by factor misallocation. Because the impact of misallocation is slightly larger in manufacturing than in services, due to larger productivity dispersion in manufacturing, sectoral output falls by more in manufacturing (54 percent) than in services (47 percent) compared to the benchmark economy. We find that accounting for entry investment roughly doubles the impact of correlated distortions on aggregate output. Overall, our results suggest an important link between policy distortions (misallocation) and technology differences across countries that substantially contributes to large differences in output per capita.[2]

Our paper builds from the seminal theories of establishment size in Lucas (1978) and Hopenhayn (1992). As such, our paper is related to a quantitative literature analyzing the size of establishments in development, for instance Barseghyan and DiCecio (2011) and Moscoso Boedo and Mukoyama (2012). A related literature emphasizes the size of the informal sector arising from financial frictions, taxes, and regulations that generate misallocation (D'Erasmo and Moscoso Boedo, 2012; Leal Ordóñez, 2014).[3] Our analysis is closely related to the literature on misallocation and aggregate productivity, but within this literature to the work emphasizing the dynamic implications of misallocation such as Hsieh and Klenow (2014), Bento and Restuccia (2017), and Guner et al. (2018). An important departure of our paper is that we emphasize the sectoral and aggregate implications of misallocation by documenting correlated distortions and average establishment size in each sector for a large set of countries. Our analysis provides a systematic quantitative evaluation of misallocation as a driver of differences in establishment size and productivity across sectors and countries. Dias et al. (2016) study factor misallocation in manufacturing and services focusing on Portugal, whereas our analysis includes a large set of countries. More importantly, we document and analyze establishment size differences across

[2] See Restuccia and Rogerson (2017) for a discussion of related work studying the broader consequences of misallocation.

[3] Hopenhayn (2016) provides a systematic evaluation of variants of the Lucas' and Hopenhayn's models for average establishment size in Latin American countries, whereas Tybout (2000) provides a broader survey of theories of establishment size in the manufacturing sector.

countries and sectors. Kumar et al. (2001) also analyze the empirical determinants of average establishment size across countries but do so in a sample that does not include all establishments and that comprises only 15 relatively developed countries in Europe.

The rest of the paper proceeds as follows. In the next section we document a newly constructed dataset on average establishment sizes in manufacturing and services sectors across a large set of countries. Section 3 discusses the main determinants of average establishment size differences across sectors and countries and relates these facts to prominent theories of development. In Section 4 we describe a two-sector model of structural transformation between manufacturing and services that features production heterogeneity in each sector. The model also features endogenous entry and productivity investment by establishments. Section 5 calibrates a benchmark economy with no distortions to U.S. data in order to assess the quantitative role of distortions on establishment size and productivity in each sector, as well as structural change and aggregate outcomes. We conclude in Section 6.

2 Average Establishment Size

We describe the construction of a newly-assembled dataset for the average employment size of service sector establishments across a large sample of countries using census or representative survey data, and show that average establishment size is strongly positively related to the level of development. We combine this dataset with data for the manufacturing sector from Bento and Restuccia (2017) to provide a more comprehensive view of establishment sizes across sectors and countries.

2.1 Data

We construct a dataset of the average employment size of service sector establishments across countries using hundreds of reports from economic censuses and nationally-representative surveys.[4] Our goal in the construction of this dataset (in conjunction with the dataset in Bento and Restuccia, 2017) is to obtain an internationally-comparable measure of average establishment size for a large sample of countries that is representative of the world income distribution, for both manufacturing and services. The primary challenges are: data availability, which typically biases country samples towards rich countries; and international comparability, due to data reported using different definitions of employment and production units, data that disproportionally include larger firms, or (especially in the case of services) having data aggregated across different groups of industries.

To assess the relationship between establishment size and development, it is crucially important that the data include all establishments regardless of whether the establishments are registered or not, and whether the establishments have paid employees or not, as a substantial portion of establishments in poor countries are unregistered and own account businesses and may include unpaid family workers. For example, paid employees account for only one quarter of persons engaged in Yemen's retail sector, while paid employees account for 95 percent of workers in U.K. retail establishments. Similarly, in Sierra Leone, 83 percent of manufacturing establishments have no paid employees, and in Ghana, unpaid workers account for almost half of the manufacturing workforce. In rich countries, by contrast, paid employees account for the bulk of persons engaged. As a result of these differences between establishments in rich and poor countries, excluding non-employer establishments generates a highly distorted picture of establishment size differences across countries. Throughout our 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. For our manufacturing dataset, we include all countries with publicly-available data representative of all manufacturing establishments or firms.[5] For services, we collect data for as many as nine service industries per country: retail; wholesale; auto repair and sales; accommodations and restaurants; finance and insurance; transportation

[4]We provide a list of countries included with the sources used for each country in Appendix A.

[5]We also include in the dataset all territories such as French Guiana, Hong Kong, and Puerto Rico. We use the word "country" solely for ease of exposition.

and storage; information and communications; art, culture, and recreation; and real estate and business services.[6] In our service sector data we include all countries with data representative of all establishments in at least one service industry. Establishments include businesses with a fixed location, as well as businesses operating out of households when a sign is posted on the premises.

In Bento and Restuccia (2017), we collected manufacturing data for as many years as possible for each country from 2000 to 2012, while service data has been collected for the year closest to 2007. Our standardized definition of size for the manufacturing sector is the average number of persons engaged per establishment across all manufacturing establishments. We use the same definition for average size in service industries. For many of the countries in our service sector sample, the data are reported as total number of persons engaged and total number of establishments. But for some industries in some countries the data are reported differently as the total number of employees, the total number of firms, or a combination of these instead of persons engaged and establishments. Table 1 summarizes the sample of countries and the reported data.[7]

To standardize the measure of size in each industry, we impute persons engaged per establishment using the reported data as follows.[8] To impute the number of persons engaged in countries that only report paid employees in a particular service industry, we regress persons engaged on employees using all countries for which both measures are reported for that industry. We then use the resulting coefficient to calculate the number of persons engaged for each country-industry that reports only employees. To impute the number of establishments in an

[6]We exclude education and health care from all countries due to wildly different levels of government control and involvement. We also exclude public administration.

[7]GDP per capita (adjusted for purchasing power parity, PPP) for most countries is from Penn World Table v. 8.0, the IMF's World Economic Outlook 2013, and the CIA World Factbook. For 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.

[8]For details of the corresponding imputations we make in our manufacturing data, see Bento and Restuccia (2017).

Table 1: Sample of Countries for Services

Variable	Total Number of Countries	Number of Poor Countries	Number of Rich Countries
persons engaged	97	49	48
employees	77	29	48
engaged and employees	47	14	33
establishments	61	34	27
firms	79	36	43
establishments and firms	13	6	7

Notes: 'Poor' and 'Rich' refer to countries with GDP per capita below and above the median. 'Number of Countries' refers to number of countries in which at least one industry reports the variable in question. Data from multiple sources, see text for details.

industry for which only the number of firms is reported, we follow an analogous procedure.[9]

Our measure of average establishment size for the entire service sector is persons engaged per establishment across all service industries. One issue that arises in constructing this size measure for the entire service sector that does not arise (at least not in a quantitatively important way) in manufacturing is that many countries report data for some but not all service industries. We therefore take the following steps to construct a comparable measure of establishment size in services across countries. First, we calculate average establishment size in a country across all service industries for which we have data. Second, we calculate average size across the same group of industries in the United States. Third, we take the ratio of average size in the country to the corresponding number in the United States and multiply this ratio by the average size in the United States across *all* service industries (equal to 4.8 persons engaged per establishment). This renders a comparable measure of average establishment size in the service sector across countries even if countries have data for only a subset of industries. This adjustment is important as there are substantial differences in average establishment size across industries within the service sector. For instance, Table 2 reports the average size of U.S. establishments in each service industry, which vary from 2 persons engaged in Art, Culture, and Recreation to

[9] These imputations follow those in Bento and Restuccia (2017) for establishments in the manufacturing sector.

15 persons engaged in Accommodations and Restaurants.

Table 2: Average Establishment Size by Service Industry, United States

Wholesale	9
Retail	6
Automobile Related	8
Accommodations and Restaurants	15
Transportation and Storage	5
Information and Communication	10
Real Estate and Business Services	3
Art, Culture, and Recreation	2
Finance and Insurance	5

In our final dataset we report the average of persons engaged per establishment across all available years for each country in services, resulting in a final sample of 127 countries. For manufacturing, we report the same measure of establishment size for a final sample of 134 countries.

2.2 Establishment Size and Development

Table 3 reports some descriptive statistics concerning average establishment size from our dataset and GDP per capita. Establishment sizes differ substantially across countries both in the manufacturing and services sectors. In addition, while average establishment sizes in the broader service sector are generally lower than in manufacturing—about one third of the size on average—establishment size in each sector is systematically lower in poor compared to rich countries, also a factor difference of 3. For example, in the poorest quartile of countries in our sample, average establishment size is 2 persons engaged in services compared to 6 persons engaged in the richest quartile of countries. In manufacturing, the difference is 6 persons engaged in poor countries compared to 17 persons engaged in rich countries. These patterns hold for individual service industries, with some industries featuring very large differences in average establishment size between the poorest and richest countries. For instance, the sub-industry of Information and Communication stands out with a factor difference in establishment size of almost 9.

Table 3: Descriptive Statistics

	Mean	Median	Poorest Quartile	Richest Quartile
Establishment Sizes (persons engaged)				
Wholesale	6	5	5	8
Retail	4	3	2	6
Automobile Related	5	4	4	6
Accommodations and Restaurants	8	4	4	10
Transportation and Storage	9	6	6	16
Information and Communication	15	8	5	43
Real Estate and Business Services	5	4	3	6
Art, Culture, and Recreation	5	4	2	10
Finance and Insurance	16	8	7	27
Services	4	4	2	6
Manufacturing	12	9	6	17
GDP per capita (thousands)	22	16	3	51

Notes: "Poorest" and "Richest" quartiles refer to the quartiles of countries with the lowest and highest GDP per capita. Data from multiple sources, see text for details.

Figure 1 documents the average establishment size in manufacturing and in services for every country in our sample with respect to GDP per capita. The data clearly show a positive correlation between average establishment size and GDP per capita in both sectors. The elasticity of establishment size with respect to GDP per capita is 0.30 in manufacturing and 0.33 in services.[10]

Figure 2 shows the average establishment size in non-agriculture (manufacturing and services) in relation to GDP per capita for 91 countries.[11] The elasticity of size with respect to GDP per

[10] The regression slope coefficient (standard error) in Figure 1A is 0.33 (0.05) and in Figure 1B is 0.30 (0.04). The corresponding numbers of countries included are 134 and 127.

[11] We calculate average size across manufacturing and services by combining our sectoral establishment-size measures with service and manufacturing shares from Duarte and Restuccia (2017), who use International Comparisons Program (ICP) data for 2005. If we denote sectoral shares in manufacturing and services by L_m and L_s, then average establishment size in non-agriculture is equal to $(L_m/size_m + L_s/size_s)^{-1}$. While 117 countries in our dataset have establishment size data for both manufacturing and services, only 91 of these have measures of sectoral shares in Duarte and Restuccia (2017).

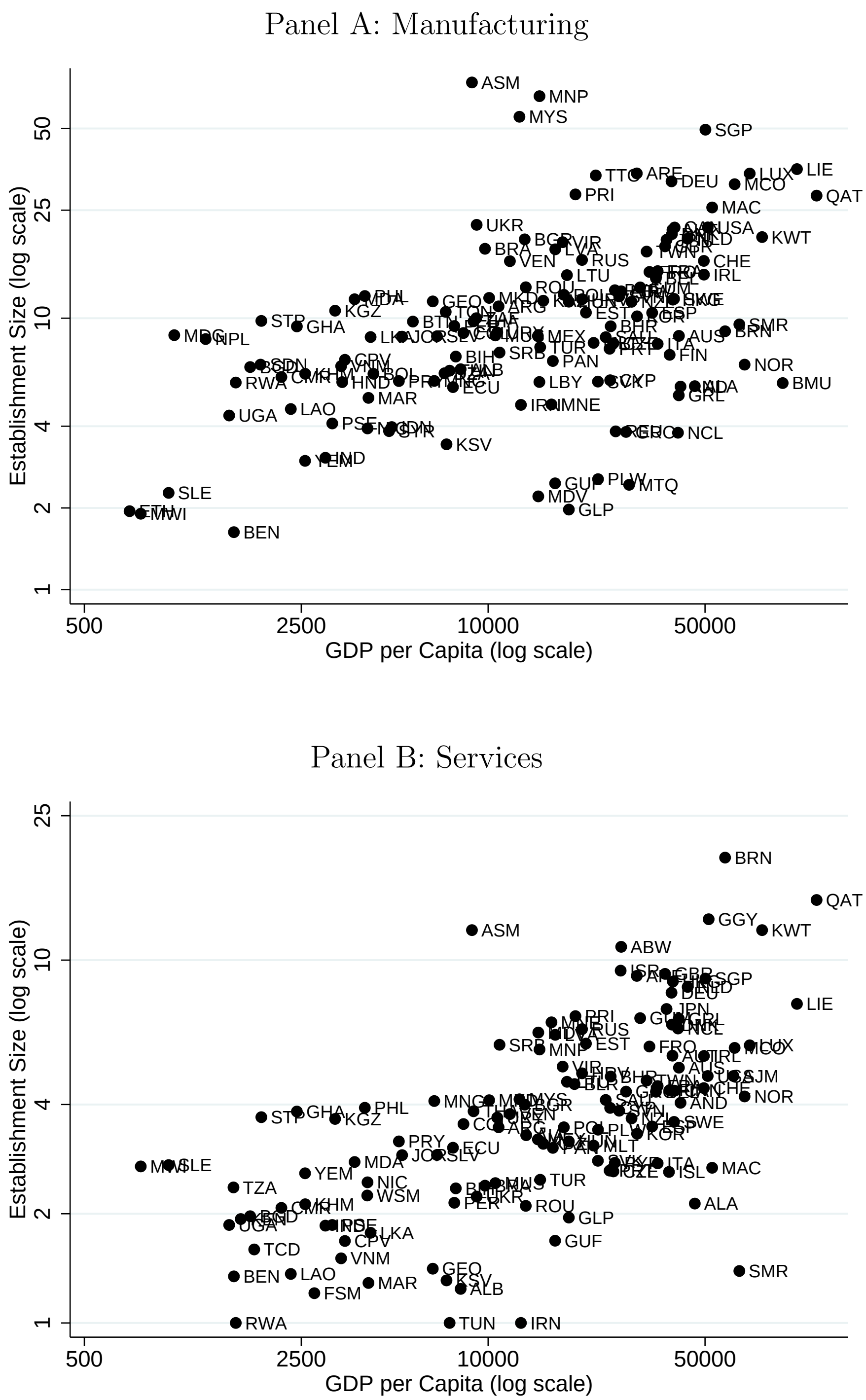


Figure 1: Establishment Size and GDP per Capita

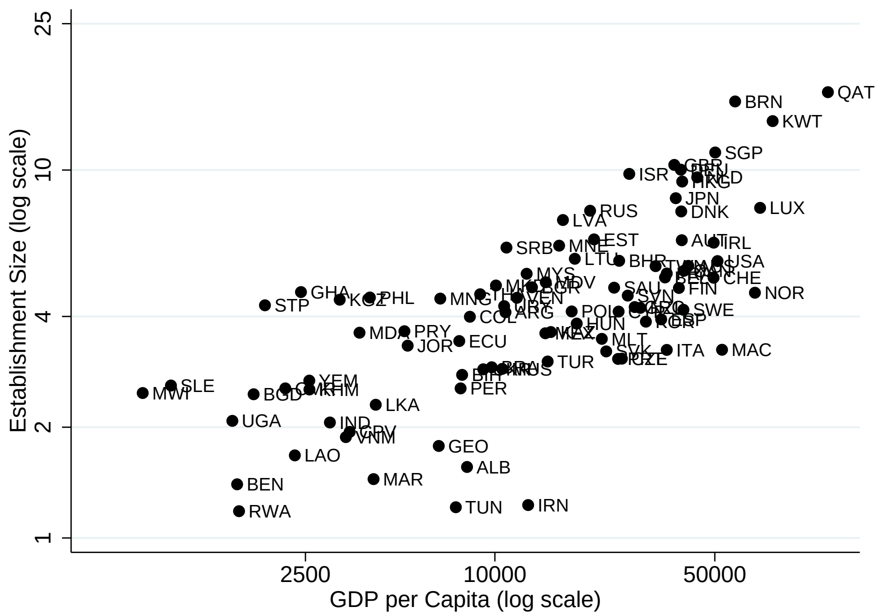


Figure 2: Establishment Size Across Sectors and GDP per Capita

capita is 0.34. This relationship is almost identical to that in Figure 1 because the corresponding elasticities for each sector are essentially the same. Moreover, the share of each sector in non-agriculture is unrelated to GDP per capita in our sample of countries.[12]

Table 4 reports the elasticity of establishment size with respect to GDP per capita for each individual service industry, as well as for the more aggregated service and manufacturing sectors. In every industry, establishment size increases with development. Although the income elasticity of average size varies across disaggregated service industries, it does not vary systematically with relative average size differences across industries. Even though the income elasticity of average establishment size is nearly identical between the aggregates of manufacturing and services of 0.3, the elasticity is as low as 0.13 for Wholesale services and as high as 0.44 for Information and Communication services. We discuss this evidence further in Section 3.2, where we relate the potential determinants of average establishment size in the data to theories of development.

[12]By being restricted to non-agriculture, this share fact is different from the systematic relationship between the share of agriculture and income per capita in the process of structural transformation, see for instance Duarte and Restuccia (2010) and Herrendorf et al. (2014).

Table 4: Income Elasticity of Establishment Size by Industry

Services	0.33
Wholesale	0.13
Retail	0.42
Automobile Related	0.22
Accommodations and Restaurants	0.33
Transportation and Storage	0.29
Information and Communication	0.44
Real Estate and Business Services	0.17
Art, Culture, and Recreation	0.40
Finance and Insurance	0.25
Manufacturing	0.30

3 Determinants of Establishment Size

An integral part of progress in any field is subjecting current theory to new data, revising theories to account for new facts and using new data to inform researchers about which theories are most useful for understanding the world. The constructed dataset of average establishment sizes across sectors and countries provides an opportunity to evaluate theories of productivity and development on their implications with respect to establishment size. In this section, we take a first step in this direction by considering a set of prominent theories and modeling specifications. We start by documenting the relationship between establishment size within each sector and measures of several relevant country-specific variables: GDP per capita, sectoral employment, openness to trade, the share of external finance to GDP, firing costs, and the elasticity of firm-level distortions with respect to firm productivity, which we label "correlated distortions". We then discuss the relevance of these relationships to several theories of development.

3.1 Data

A set of several relevant data series is collected from different sources. GDP per capita is expressed in PPP terms and is taken mainly from Penn World Tables v8.0 (PWT) but also several other sources as discussed in Section 2.1. Openness to trade is from the PWTv8.0, calculated as the value of imports plus exports as a share of GDP. Sectoral employment is the number of persons engaged in a sector.[13] External finance measures the aggregate level of firm-level investment not financed internally, relative to GDP. We use a measure of external finance from Buera et al. (2011), calculated using data from Beck et al. (2010). Firing costs are from the OECD's Indicators of Employment Protection Legislation for 2008, which account for both individual and collective employee dismissals, and from Heckman and Pagés (2004).[14] Firing costs measures the cost to a firm of firing a worker, both monetary and non-monetary (such as mandatory minimum notice before dismissal).

We construct sectoral measures of correlated distortions for each country using establishment-level data from the World Bank's Enterprise Surveys. This dataset includes data from mostly low- and middle-income countries collected through face-to-face surveys, and 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 from 2002 to 2012.[15] We back out our measure of establishment-level distortions and productivity for each establishment within a country-industry-year by imposing the following structure on the data.[16] Assume establishments within an industry differ with respect to their productivity Z, and produce output according to the following decreasing returns to scale technology;

$$y = Z\ell^{\alpha}, \tag{1}$$

where $\alpha \in (0, 1)$ and ℓ denotes labor.[17] Assuming establishments take the price of output p and

[13]Specifically, we use the sectoral share of manufacturing and services in Duarte and Restuccia (2017) multiplied by population from the PWTv8.0. We use population rather than total persons engaged due to a lack of total engaged data for many countries. Note that the sectoral share in Duarte and Restuccia (2017) refers to the share of expenditures in manufacturing or services relative to total expenditures in manufacturing and services expressed in domestic prices. This share maps into employment shares in standard models of structural transformation. We use this data since it provides the largest country coverage. Nevertheless, the results are nearly identical using actual employment data across sectors from the 10-sector database for a restricted set of countries with available data.

[14]To combine the different measures of firing costs, we regress the (logged) measures from the OECD on those from Heckman and Pagés (2004), then construct predicted measures consistent with the OECD data for countries included in Heckman and Pagés (2004) but not included in the OECD data.

[15]See Bento and Restuccia (2017) for more details about the data.

[16]The structure we impose is consistent with the model we develop in Section 4.

[17]We abstract from capital in our measures because this allows us to increase substantially the number of

the wage w as given, each establishment optimally chooses ℓ such that its after-tax marginal revenue product is equal to the prevailing wage w.[18] This suggests the following relationship between an establishment's labor productivity and its distortion (which we model as an explicit tax on output);

$$\frac{py}{\ell} = \frac{1}{(1-\tau)}\left(\frac{w}{\alpha}\right) \propto \frac{1}{(1-\tau)},$$

where py is an establishment's value added (sales minus intermediate inputs).[19] Establishment-level productivity (denoted by Z) is inferred under the same assumptions using the model-implied relationship between an establishment's revenue and its output;[20]

$$Z = \frac{y}{\ell^{\alpha}} \propto \frac{py}{\ell^{\alpha}}.$$

Following Hsieh and Klenow (2014) and Bento and Restuccia (2017), we then run an OLS regression of logged distortions on logged productivity across establishments to obtain each country's productivity elasticity of distortions.[21] Some countries have data for two or more years, so we average elasticities over all years, weighting by the number of observations in each year. We obtain elasticities for 74 countries in the manufacturing sector and for 63 countries in the service sector. In manufacturing, elasticities range from 0.37 to 1.08, averaging 0.78. In services, elasticities range from 0.36 to 1.09, averaging a higher 0.87. Countries with a higher productivity elasticity of distortions in manufacturing also tend to have a higher elasticity in services. The corresponding correlation coefficient between the two sectoral measures of

establishments for each country and the number of usable countries, as a large number of establishments in the Surveys do not report capital. Nevertheless, it is well-known that empirical measures of wedges for different factor inputs are highly correlated so they are well captured by a composite output wedge.

[18]We provide more details about the model in Section 4.

[19]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. Our measure of labor productivity for each establishment is calculated *relative to* the weighted average of labor productivity across all establishments within the same industry, weighted by each establishment's share of value added.

[20]Following Hsieh and Klenow (2009), productivity is calculated relative to industry productivity in the absence of distortions, $\left[\text{mean}\left(Z^{(1/(1-\alpha))}\right)\right]^{1-\alpha}$.

[21]Hsieh and Klenow (2014) perform this procedure for the U.S., India, and Mexico. 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.

distortions is 0.46.

Figure 3 illustrates how our sectoral measures of correlated distortions vary with GDP per capita.[22] In both manufacturing and services, distortions rise more quickly with productivity in poorer countries.

3.2 Theories of Development

In order to provide evidence on the determinants of average establishment size across sectors and countries, we generate reduced-form relationships between establishment size and several indicator variables at the core of prominent theories of productivity and development. Tables 5 through 8 document the estimated coefficients from bivariate and multivariate regressions of average establishment size on subsets of country-specific variables such as GDP per capita, openness to trade, firing costs, external finance, and correlated distortions.[23] Table 9 reports the results for the ratio of average establishment size in manufacturing and services. In what follows, we discuss these results in the context of several theories of development and aggregate productivity.

Entry Costs A number of papers, including Barseghyan and DiCecio (2011), Moscoso Boedo and Mukoyama (2012), and Bento (2014b), consider entry costs (the cost of starting a firm) as a potential source of low productivity in poor countries. Entry costs reduce entry and the number of firms in equilibrium, increasing the size of firms above their optimal size and thereby lowering aggregate productivity. There is no good data on entry costs, but the positive relationship between size and GDP per capita in Tables 5 and 7 suggest that entry costs are not in fact higher in poor countries.[24]

[22]We include the U.S. for comparison even though it does not appear in the Enterprise Surveys data. Hsieh and Klenow (2009) suggest the productivity elasticity of distortions in U.S. manufacturing is zero, and we assume the same for U.S. services.

[23]We restrict our multivariate regressions to subsets of explanatory variables for which we have at least 30 observations.

[24]Several papers have used the World Bank's (2018) Doing Business variable 'startup cost' as a measure of regulatory entry costs, including Bento (2014b). But according to the World Bank, this variable measures the

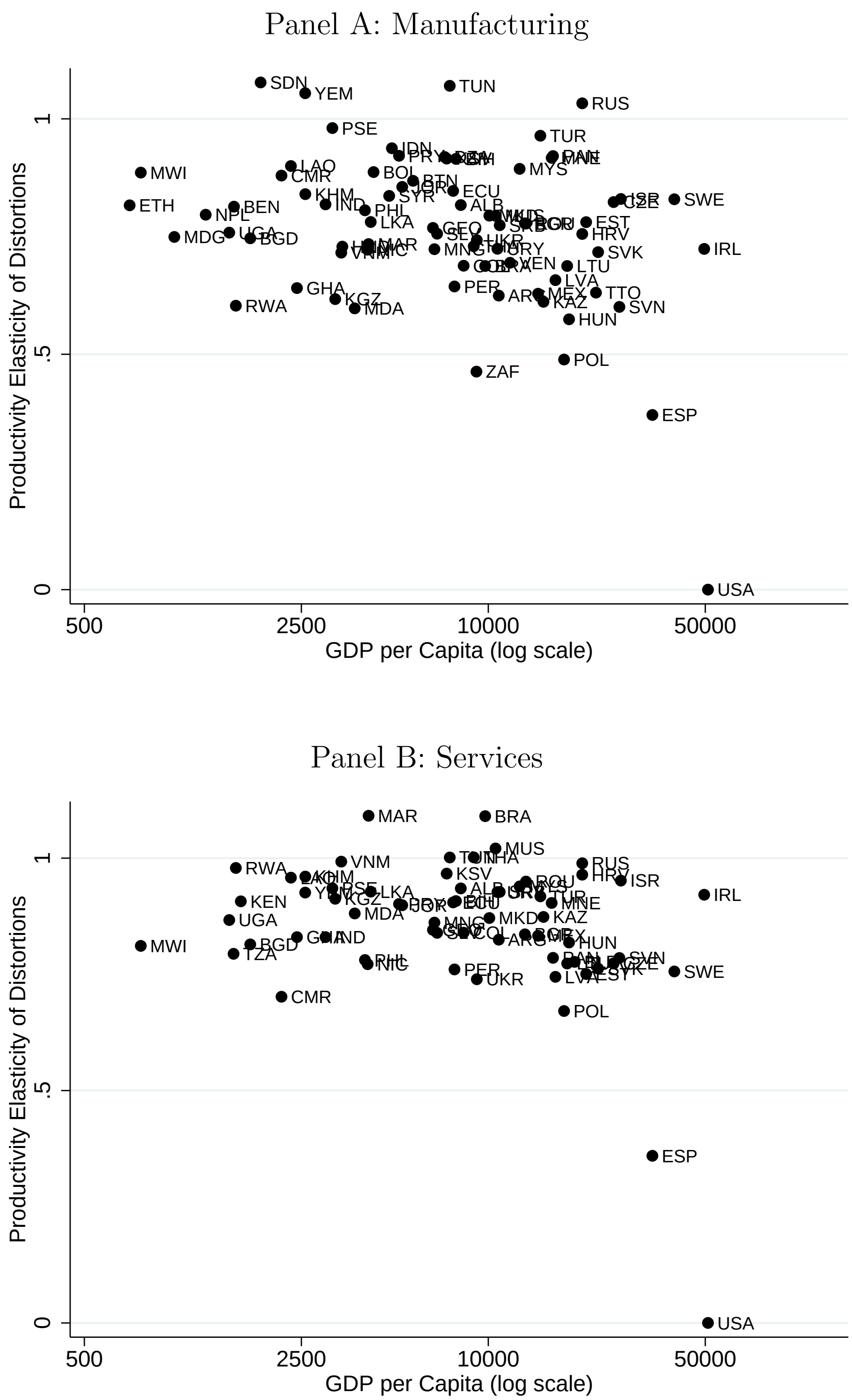


Figure 3: Productivity Elasticity of Distortions and GDP per Capita

Table 5: Determinants of Size in Manufacturing—Bivariate

Dependent variable:	Average Establishment Size—Manufacturing					
Independent variables:						
GDP per capita	0.30***					
	(0.05)					
Mnfg. employment		0.03				
		(0.05)				
External financing			0.42***			
			(0.06)			
Firing costs				-0.31***		
				(0.08)		
Openness to trade					0.41***	
					(0.11)	
Correlated distortions (Mnfg.)						-1.46***
						(0.31)
Countries	134	74	56	52	95	75
R^2	0.22	0.01	0.43	0.15	0.19	0.15

Notes: All variables logged, except for correlated distortions. See the text for the definition of variables and sources. Robust standard errors in parentheses. *** refers to a one percent level of significance.

A related issue is the modeling of entry costs (and other fixed costs) in quantitative models. Many authors specify fixed costs in their models in terms of goods, while others specify fixed costs in terms of fixed factors such as labor. The choice of how costs are specified can have both qualitative and quantitative implications for how various policies affect aggregate outcomes. It also has stark implications for average establishment size in growing economies. If wages grow along with GDP per capita, then a labor cost of entry grows proportionately, which in many models implies a constant number of firms per capita and a constant average firm size. Instead, a goods cost of entry in a growing economy shrinks relative to the operating profits of firms, implying more entry and smaller firms on average. Bollard et al. (2016) examine firm-level panel data from the U.S., China, and India, and conclude that average firm size does not shrink over time in growing economies, suggesting that fixed costs in a model should be specified in terms of a fixed factor such as labor rather than (purely) goods. The positive coefficients on GDP

cost of incorporating a large firm, not the cost of starting a firm.

Table 6: Determinants of Size in Manufacturing—Multivariate

Dependent variable:	Average Establishment Size—Manufacturing					
Independent variables:						
External financing	0.21*	0.38***	0.29**			
	(0.11)	(0.07)	(0.11)			
Firing costs	-0.17*			-0.29***	-0.20*	
	(0.10)			(0.08)	(0.12)	
Openness to trade		0.17		0.16		0.31**
		(0.13)		(0.12)		(0.13)
Correlated distortions (Mnfg.)			-1.22***		-0.81**	-1.29***
			(0.41)		(0.37)	(0.35)
Countries	38	50	34	47	32	60
R^2	0.26	0.50	0.43	0.20	0.26	0.25

Notes: All variables logged, except for correlated distortions. See the text for the definition of variables and sources. Robust standard errors in parentheses. ***, **, and * refer to one, five, and ten percent levels of significance.

per capita in Tables 5 and 7 suggest that specifying fixed costs in terms of goods generates counter-factual implications with respect to the cross-country data as well. Establishments are definitely not smaller in rich countries, neither in manufacturing nor in services.

Financial Constraints Buera et al. (2011, 2015) develop what has since become a workhorse model of heterogeneous firms with financial constraints, building on Hopenhayn (1992). In the one-sector version of the model, the effect of financial constraints on average firm size is theoretically ambiguous. Financial constraints lead to slower firm growth, which encourages entry due to lower average productivity among incumbents, as noted by Atkeson and Burstein (2010). But potential entrepreneurs must accumulate savings in order to self-finance fixed costs, which lowers entry. In the two-sector version of the model, where sectors are differentiated with respect to the size of fixed costs (larger in manufacturing than in services), Buera et al. (2011) specification of fixed costs in terms of sectoral output results in less ambiguous predictions. Financial constraints bite harder in manufacturing, as potential entrepreneurs must save longer to start a (relatively) large manufacturing firm. As a result, the relative price

Table 7: Determinants of Size in Services—Bivariate

Dependent variable:	Average Establishment Size—Services					
Independent variables:						
GDP per capita	0.33***					
	(0.04)					
Services employment		-0.00				
		(0.04)				
External financing			0.30***			
			(0.06)			
Firing costs				-0.25***		
				(0.08)		
Openness to trade					0.39***	
					(0.08)	
Correlated distortions (Serv.)						-0.81***
						(0.29)
Countries	127	82	53	49	100	64
R^2	0.39	0.00	0.36	0.18	0.21	0.07

Notes: All variables logged, except for correlated distortions. See the text for the definition of variables and sources. Robust standard errors in parentheses. *** refers to a one percent level of significance.

of manufacturing increases. This relative change creates an additional wedge between the ease of entry in manufacturing and services, as the fixed cost of manufacturing output becomes more costly. The result is a larger average size in manufacturing, and a smaller average size in services.

Tables 5 through 8 document a positive relationship between average size and the extent of external financing in an economy, both for manufacturing and service establishments. The extent of external financing is a widely-used proxy for financial constraints, as the theory predicts a monotonically negative relationship between the extent of constraints and external financing. The results in Tables 5 and 6 are inconsistent with the prediction of the model that manufacturing firms should be larger with tighter financial constraints and less external financing. Moreover, Table 9 suggests the ratio of average size in manufacturing to that in services is uncorrelated with financial constraints. Table 4 also suggests that average size differences across industries are uncorrelated with GDP per capita. To the extent that financial

Table 8: DETERMINANTS OF SIZE IN SERVICES—MULTIVARIATE

Dependent variable:	Average Establishment Size—Services			
Independent variables:				
External financing	0.21***	0.22***		
	(0.06)	(0.07)		
Firing costs	-0.11		-0.24***	
	(0.07)		(0.08)	
Openness to trade		0.22**	0.12	0.25***
		(0.10)	(0.08)	(0.09)
Correlated distortions (Mnfg.)				-0.73***
				(0.26)
Countries	37	53	48	61
R^2	0.34	0.41	0.22	0.19

Notes: All variables logged, except for correlated distortions. See the text for the definition of variables and sources. Robust standard errors in parentheses. *** and ** refer to one and five percent levels of significance.

constraints are more of a problem in poor countries, the disaggregated industry data also seems inconsistent with the theory.[25]

Firing Costs Hopenhayn and Rogerson (1993) extend the model of firm dynamics in Hopenhayn (1992) to theoretically and quantitatively evaluate the impact of imposing firing costs on firms. The literature that has followed has largely built upon this seminal paper. Hopenhayn and Rogerson (1993) find that firing costs dampen the response of firms' labor decisions to productivity shocks, lower aggregate employment, and reduce TFP due to a misallocation of labor across firms and fewer firms in equilibrium. Average firm size is predicted to increase with firing costs. This prediction is inconsistent with the data as suggested by the results in Tables 5 through 8. Among economies with data on firing costs, higher firing costs are associated with smaller establishments, both in services and manufacturing. Although the coefficients are not

[25] We conjecture that if fixed costs were instead specified in terms of labor, the relative price change between sectors would no longer add an additional wedge to the cost of entry in manufacturing relative to services (or in industries with high entry costs relative to those with low entry costs). Further, labor entry costs would encourage entry in both one-sector and two-sector models as lower wages due to financial constraints would endogenously lower fixed costs, generating predictions in the context of a growing economy more in line with the evidence.

Table 9: DETERMINANTS OF SIZE RATIO MANUFACTURING TO SERVICES

Dependent variable:	Ratio of Average Sizes—Manuf. to Services					
Independent variables:						
GDP per capita	0.01					
	(0.06)					
Employment ratio (M/S)		0.29				
		(0.33)				
External financing			0.13			
			(0.09)			
Firing costs				-0.04		
				(0.10)		
Openness to trade					0.03	
					(0.09)	
Correlated distortions gap (M-S)						-1.19**
						(0.47)
Countries	117	91	50	48	95	61
R^2	0.00	0.01	0.07	0.01	0.00	0.08

Notes: All variables logged, except for correlated distortions. See the text for the definition of variables and sources. Robust standard errors in parentheses. ** refers to a five percent level of significance.

significant across all specifications, they are all negative. It is important to note that Hopenhayn and Rogerson (1993) predict a quantitatively small effect on firm size, which we might not pick up with so few observations and controls. But the negative relationship between firing costs and establishment size suggests that more research into the mechanisms through which firing costs operate is needed. One mechanism that we highlight below is that misallocation generated by firing costs also induce a change in establishment-level productivity, potentially reversing the implication on establishment size.[26]

Endogenous Markups Several strands of the development literature have incorporated endogenous markups in models of firm size. Melitz and Ottaviano (2008) and Desmet and Parente (2010), for example, use endogenous markups to (among other things) investigate the pro-competitive gains from trade, while Bento (2014a) incorporates endogenous markups in a

[26]See Da-Rocha et al. (2016) and Da-Rocha et al. (2017) for frameworks where firing costs and misallocation induce changes in the productivity distribution.

model of innovation in order to rationalize empirical relationships between competition and innovation. All models with endogenous markups and endogenous firm size, to our knowledge, predict a positive relationship between population and firm size.[27] In models with constant markups, for example Melitz (2003), an increase in population results in a proportional increase in the number of firms, leaving average firm size unchanged. But if markups are endogenous and depend on the number of competitors, more firms leads to lower markups, thereby lowering profits (relative to the constant markup case). As a result, the number of firms increases less than population, and average firm size is larger. Tables 5 and 7 show that establishment size in services and manufacturing are unrelated to sectoral employment (the product of population and the sectoral share of employment). Although not shown, average establishment size in each sector is also unrelated to population. Interpreted through the lens of models with endogenous markups, these results suggest that while larger populations are associated with more firms, they are not associated with more competition.

Trade Models of international trade imply that the relationship between openness to trade and firm size depends on which trade barrier is driving the variation in openness—tariffs vs. fixed trade costs (Melitz, 2003), fixed firm-specific vs. product-specific trade costs (Bernard et al., 2011). For example, lowering tariffs across countries should cause exporters to expand while firms who only sell domestically contract or exit in response to the increase in imports, resulting in larger firms. Table 5 reports a positive relationship between establishment size in manufacturing and openness to trade, consistent with variation in tariffs (and distance-related costs) as the dominant driving force behind differences in the extent of trade across countries. But this result is not robust across all specifications in Table 6. Further, Table 7 reports an identical unconditional relationship between openness to trade and average establishment size in services, and Table 9 shows that the relative size of establishments in manufacturing relative to

[27] One exception is Bento (2018b) where firms face a market-entry cost which is increasing in the number of markets entered. If the number of markets in an economy increases with population, then so does the number of firms, but each firm continues to serve the same number of markets. As a result, the number of firms in each market is independent of population.

services is unrelated to how open a country is to trade. To the extent that goods are more likely to be traded than services, the data seems inconsistent with tariffs driving average size. Rather, the data seems consistent with differences in openness to trade across countries being driven by variation in several types of trade barriers, with no one barrier dominating empirically.[28]

Correlated Distortions A recent but growing literature evaluates the impact of misallocation when the wedges faced by firms are dependent on firm characteristics that are in part chosen by firms. For instance, Hsieh and Klenow (2014), Bento and Restuccia (2017), and Guner et al. (2018) consider models of misallocation where firms face distortionary effective taxes that depend on firm productivity, and firms take this into account when choosing their productivity. In addition to the impact on aggregate productivity from the misallocation of inputs across firms, correlated distortions reduce the marginal incentive of firms to invest in productivity, further reducing aggregate productivity and lowering average firm size. The empirical results in Tables 5 through 9 are consistent with this broad theory. Average establishment size in each sector is declining in the extent of correlated distortions, and the ratio of average size in manufacturing relative to services is decreasing in the difference between correlated distortions in the two sectors. Note that the type of misallocation (correlated distortions) considered in this literature comprises many types of policies and institutions that are know to create the specific patterns including informality, financial frictions, selective regulation, firing costs, trade policy, among others. For example, financial frictions impact disproportionally more the more productive establishments as the credit friction is likely to affect more their optimal size, thus reducing the return to investment in productivity and decreasing the average size of establishments. In calculating the extent of correlated distortions using the reported decisions of establishments, our measure of correlated distortions captures the net impact of many policies and institutions working through this mechanism.

To summarize, of the theories of development just discussed, misallocation (due to finan-

[28] It is worth noting that the service sector has been explored less intensively in the trade literature. It is possible that incorporating inter-sectoral linkages and/or trade in services may generate richer implications for relative establishment sizes from trade.

cial constraints, firing costs, or correlated distortions more broadly) appears to be the most promising in driving establishment size differences across sectors and countries.[29] Models of correlated distortions with endogenous establishment size and productivity generate qualitative predictions consistent with the establishment size data. In the next section, we incorporate correlated distortions into a two-sector model to assess the impact on sectoral average establishment size, and to quantify the impact of correlated distortions on sectoral and aggregate productivity.

4 A Model of Size across Sectors and Countries

We develop a two sector model of establishment size and structural transformation. We focus on the non-agricultural sector and hence the environment includes manufacturing and services.[30] There is a stand-in household (of measure one) endowed with one unit of productive time, and there are two goods produced in sectors: manufacturing and services. The production unit in each sector is an establishment operating with a decreasing returns to scale technology.[31] There are a large number of potential firms who are free to enter, but must pay a fixed entry cost and make a costly productivity-investment decision before producing. Producers face output distortions which may be correlated with firm-level productivity, and entrants take these policy distortions into account when investing in productivity. We assume a static economy for simplicity, but none of our qualitative or quantitative results depend on this assumption. We study a competitive equilibrium of the economy in which firms take prices as given and free entry ensures the value of entry is driven to zero. We then consider how the extent of

[29]See also Hopenhayn (2016) on this point. Although the R^2's in Tables 5 through 9 suggest financial constraints can explain more of the variance in average size across countries, this is simply a reflection of the different samples of countries used in each regression. For example, if we replicate the regressions in columns 3 and 6 from Table 5 using only countries with measures of both external financing and correlated distortions, the R^2's are very similar. Further, the R^2 increases by 50% when both variables are included in the regression (column 3, Table 6).

[30]We abstract from agriculture as the details of the production unit and the relevant definition of size are different for agriculture than for the rest of the economy. Nevertheless, the same economics emphasized for non-agricultural establishments applies for agriculture as well, see for instance Adamopoulos and Restuccia (2014) for evidence on farm size across countries and a model emphasizing the role of misallocation in agriculture.

[31]Throughout we use the terms 'firm', 'producer', and 'establishment' interchangeably.

correlated distortions affects the number of firms, investment, and aggregate output. We begin by describing the environment in more detail.

4.1 Economic Environment

Preferences and Endowments There is a representative household of measure 1 that is endowed with one unit of productive time and has preferences for manufacturing (m) and service (s) goods according to the following utility function,

$$U(C_m, C_s) = [bC_m^\rho + (1-b)C_s^\rho]^{1/\rho}, \quad b \in (0,1), \quad \rho < 0. \tag{2}$$

The household is endowed with one unit of productive time each period that is supplied inelastically to the market.

Technologies In each sector, an homogeneous good is produced in establishments. An establishment produces output y according to the following production function,

$$y(h, z, \ell; i) = A_i h z \ell^\alpha,$$

where ℓ is labor, A_i is a sector-wide productivity term, h and z are idiosyncratic productivity terms, and $\alpha \in (0,1)$. Of the productivity terms, h is chosen by the firm upon entering the market with a sector-specific labor cost $wc_h^i h^\theta$ with $c_h^i > 0$ and where w denotes the real wage; and z is exogenous and known after entering and investing in h according to a distribution with *cdf* $F(z)$. There are a large number of potential firms, each of which can become a producer by incurring a sector-specific labor cost of entry wc_e^i with $c_e^i > 0$.

Market Structure and Distortions Consider a competitive economy where households and firms take prices as given. There are a large number of firms operating in the manufacturing and services sectors, renting labor services from consumers at the rate w and selling consumption goods to households at prices p_m and p_s. In each sector, producers face a proportional tax on revenue τ which depends on firm-level productivity in the following way,

$$1 - \tau(h, z; i) = \kappa_i \cdot (hz)^{-\gamma_i}, \quad \gamma_i \geq 0. \tag{3}$$

where γ_i is the elasticity of distortions with respect to productivity in sector i and κ_i is a level shifter that changes with γ_i to ensure that the sectoral average weighted distortion (weighted by each firm's sectoral revenue share) is constant across different levels of γ_i. This allows us to isolate the impact of a higher productivity elasticity of distortions, keeping average distortions constant.[32] In what follows, we assume that this average tax is equal to zero.

Definition of Equilibrium A *competitive equilibrium* is a list of prices (w, p_m, p_s), decision functions for firms in each sector: labor demand $\ell(h, z)$, operating profits $\pi(h, z)$, endogenous productivity h_i, value of entry V_e^i, and number of firms N_i in each sector; and allocation for consumers: C_m, C_s such that;

(*i*) Given w, p_s, and p_m; allocation (C_m, C_s) solves the household problem, i.e. maximizes utility subject to the budget constraint.

(*ii*) Given w, p_s, and p_m; producers in each sector choose labor $\ell(h, z)$ to maximize per-period operating profits $\pi(h, z)$, which in turn determine the value of an incumbent producer.

(*iii*) Given w, p_s, and p_s; entrants choose productivity h_i in each sector to maximize the expected value of operating profits net of investment.

(*iv*) Free entry $V_e^i = 0$ in each sector ensures that the expected value of operating profits is equal to the optimal productivity investment plus the entry cost.

[32]Considering different levels of γ_i while keeping the average distortion constant is consistent with the counterfactuals examined in Hsieh and Klenow (2009) and Bento and Restuccia (2017). Note that if these distortions are interpreted literally as taxes, keeping the average distortion constant as γ_i increases ensures that aggregate tax revenue net of subsidies is kept constant.

(v) Markets clear, i.e., the supply of labor (equal to one) is equal to the quantity of labor demanded by firms plus the entry and investment costs of labor; and the supply and demand of the output good are equal.

4.2 Characterization

The household problem is simply to maximize utility subject to the budget constraint by choosing consumption in each sector,

$$\max \; [bC_m^\rho + (1-b)C_s^\rho]^{1/\rho},$$

subject to

$$p_m C_m + p_s C_s = w.$$

The solution to this problem (C_m, C_s) satisfies,

$$\frac{b}{1-b}\left(\frac{C_m}{C_s}\right)^{\rho-1} = \frac{p_m}{p_s}, \tag{4}$$

and the budget constraint specified above.

A producer with productivity hz in sector i solves the following problem,

$$\max_{\ell} \; (1-\tau(h,z;i))p_i y(h,z,\ell;i) - w\ell,$$

where $y(h,z,\ell;i) = A_i hz\ell^\alpha$ and $(1-\tau(h,z;i)) = \kappa_i \cdot (hz)^{-\gamma_i}$, which implies the following optimal output $y(h,z;i)$ and operating profits $\pi(h,z;i)$,

$$y(h,z;i) = (A_i hz)^{\frac{1}{1-\alpha}} \left(\frac{\alpha p_i \cdot (1-\tau(h,z;i))}{w}\right)^{\frac{\alpha}{1-\alpha}}, \tag{5}$$

$$\pi(h,z;i) = \left(\frac{\alpha^\alpha p_i \cdot (1-\tau(h,z;i))A_i hz}{w^\alpha}\right)^{\frac{1}{1-\alpha}}(1-\alpha). \tag{6}$$

Before learning z and producing, an entrant to sector i must choose h to solve the following problem,

$$\max_h \; \mathbb{E}[\pi(h, z; i)] - wc_h^i h^\theta,$$

which implies

$$wc_h^i h_i^\theta = \left(\frac{1 - \gamma_i}{(1 - \alpha)\theta} \right) \mathbb{E}_z[\pi(z; i)]. \tag{7}$$

Finally, free entry ensures that firms enter each sector until expected operating profits net of productivity investment is exactly equal to the cost of entry,

$$wc_e^i = \left(\frac{(1 - \alpha)\theta - 1 + \gamma_i}{(1 - \alpha)\theta} \right) \mathbb{E}_z[\pi(z; i)]. \tag{8}$$

Note that equations (7) and (8) together imply the following h is chosen by firms in each sector,

$$h_i = \left(\frac{c_e^i (1 - \gamma_i)}{c_h^i [(1 - \alpha) - 1 + \gamma_i]} \right)^{\frac{1}{\theta}}. \tag{9}$$

The average (weighted) distortion in each sector is characterized by the following expression,

$$1 - \overline{\tau_i} = \frac{\mathbb{E}_z[y(z; i)(1 - \tau(z; i))]}{\mathbb{E}_z[y(z; i)]}. \tag{10}$$

To keep $\overline{\tau_i}$ equal to zero across different values of γ_i, we set κ_i equal to

$$\kappa_i = h_i^{\gamma_i} \frac{\mathbb{E}_z \left[z^{\frac{1 - \alpha\gamma_i}{1 - \alpha}} \right]}{\mathbb{E}_z \left[z^{\frac{1 - \gamma_i}{1 - \alpha}} \right]}. \tag{11}$$

Combining equations (5), (6), (8), and (11), we can now derive the average size of firms in each sector. If N_i and L_i denote the number of firms and the quantity of labor in sector i, then average firm size in sector i is

$$\frac{L_i}{N_i} = \frac{\theta c_e^i}{(1 - \alpha)\theta - 1 + \gamma_i}. \tag{12}$$

We note that average size in each sector is increasing in entry costs c_e^i and decreasing in

γ_i. Average size is *not* dependent on exogenous sectoral productivity. Average size is also independent of exogenous aggregate productivity.

Equations (5), (12), labor-market clearing, and goods-market clearing can be combined to derive measured TFP in each sector;

$$TFP_i \equiv \frac{C_i}{L_i} = \frac{\alpha^\alpha}{\theta^{1-\alpha}} A_i \left(\frac{1-\gamma_i}{c_h^i}\right)^{\frac{1}{\theta}} \left[\frac{(1-\alpha)\theta - 1 + \gamma_i}{c_e^i}\right]^{\frac{(1-\alpha)\theta-1}{\theta}} \frac{\mathbb{E}_z\left[z^{\frac{1-\alpha\gamma_i}{1-\alpha}}\right]}{\mathbb{E}_z\left[z^{\frac{1-\gamma_i}{1-\alpha}}\right]^{\alpha}}. \tag{13}$$

Sectoral TFP is increasing in exogenous productivity A_i, and decreasing in the costs of entry and productivity investment (c_e^i and c_h^i) as well as the productivity elasticity of distortions γ_i. The first two bracketed terms in the TFP_i expression in equation (13) represent the combined effects of $(c_e^i, c_h^i, \gamma_i))$ on the number of firms per worker N_i and the endogenous productivity term h_i, which affect TFP_i in opposite ways. The last term in equation (13) represents the negative effect on aggregate TFP_i arising from misallocation due to distortions γ_i.

The price of manufactured goods, relative to services, is

$$\frac{p_m}{p_s} = \frac{TFP_s}{TFP_m}. \tag{14}$$

We solve for sectoral labor shares by combining the above results with equation (4) from the household's problem. The shares of labor allocated to each sector are:

$$L_m = \frac{\Psi}{\Psi+1}; \qquad L_s = \frac{1}{\Psi+1}, \tag{15}$$

where

$$\Psi \equiv \left(\frac{b}{1-b}\right)^{\frac{1}{1-\rho}} \left(\frac{TFP_m}{TFP_s}\right)^{\frac{\rho}{1-\rho}}.$$

In the Cobb-Douglas case, $L_m = b$ when ρ goes to 0, and sectoral shares do not depend on sectoral productivities. When $\rho < 0$ and when the ratio of productivity in manufacturing to services is larger, then the share of labor in services is larger. In a dynamic version of the model, if labor productivity growth is faster in manufacturing than in services, then labor reallocates over time from manufacturing to services.

We define real GDP as equivalent to $U(C_m, C_s)$. If the price of a unit of real GDP is normalized to one, then GDP is equal to the wage w. Using equations (2), (13), (14), and (15), we can express the wage as

$$w = (\Psi + 1)^{-1} \left[b \cdot TFP_m^{\rho} \cdot \Psi^{\rho} + (1-b) \cdot TFP_s^{\rho} \right]^{\frac{1}{\rho}},$$

or

$$w = (1-b)^{\frac{1}{\rho}} \cdot TFP_s \cdot (1+\Psi)^{\frac{1-\rho}{\rho}}. \tag{16}$$

5 Quantitative Analysis

We calibrate a benchmark economy with no distortions to U.S. data. We use the calibrated model to quantify the implications of cross-country variations in the degree of correlated distortions and entry costs in each sector on establishment size and productivity in each sector; and on structural change and aggregate output .

5.1 Calibration

We calibrate a benchmark economy with no distortions to U.S. data, i.e. in the model we set $\overline{\tau}_i$ and γ_i to zero in each sector. The parameters to calibrate are: preferences (b,ρ), entry and productivity investment costs (c_e^i,c_h^i), technology (α,θ), and exogenous productivity distributions (A_i,$F(z)$). We assume $c_h^i = 1$ in both sectors since our model cannot separately identify the level of costs c_h^i and exogenous sector productivity A_i.

We assume $\alpha = 2/3$ which maps into the curvature parameter used in the monopolistic competition model of Hsieh and Klenow (2009), where the elasticity of substitution between varieties is assumed to be 3. For θ, we choose this parameter to match the elasticity of revenue with respect to investment in productivity reported in Bento and Restuccia (2017), equal to 0.72. In our model, this elasticity is equal to

$$\frac{1-\alpha\gamma_i}{(1-\alpha)\theta}.$$

With the value of α and assuming $\gamma_i = 0$ in the U.S. data in both sectors, we obtain $\theta = 4.17$. We choose c_e^i to match average size in manufacturing and services from equation (12) in the United States, obtaining $c_e^m = 2.02$ and $c_e^s = 0.45$. From Duarte and Restuccia (2010), we select $\rho = -1.5$. Given ρ and a target for the relative price of manufacturing to services, we obtain $b = 0.05$ to match U.S. sectoral shares from equation (15).

We obtain distributions of z for each sector in our benchmark economy by interpreting the employment-size distributions of establishments in the United States through the lens of our model. For this purpose we use data from the U.S. Census Bureau. Our model with no distortions implies a simple mapping between productivity z and employment in equation (5), such that the labor demand of establishment i relative to that of establishment j is;

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

Adjusting the data to account for both paid and unpaid workers, we obtain separate distributions of persons engaged per establishment in manufacturing and services ranging from 1 to 3000 persons. In each sector, we match exactly the fraction of establishments falling within each size bin, illustrated in Figure 4. The size distribution of establishments in services is more skewed to the right than in manufacturing, with less dispersion in size among service establishments. For our calibrated productivity distributions, we assume the productivity of establishments within each bin are uniformly distributed.

This completes the calibration for the benchmark economy. We now characterize parameters that differ across countries. We assume countries are otherwise identical to the benchmark economy except on 6 exogenous parameters: the productivity elasticity of distortions γ_i, entry

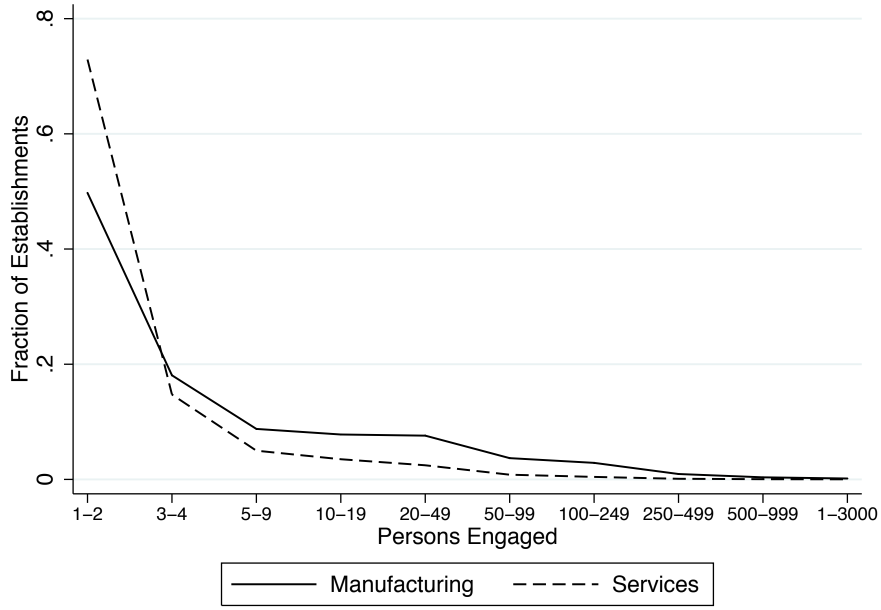


Figure 4: Establishment Size Distributions, U.S. Data

costs c_e^i, and exogenous productivity A_i in each sector i. The values of γ_i for each sector and country are given by the data reported earlier in Figure 3. We choose c_e^i in each sector and country to match the average establishment size data across sectors and countries reported in Figure 1. Combining the above values with sectoral shares in each country from Duarte and Restuccia (2017), we back out the ratio of exogenous productivity between manufacturing and services A_m/A_s using equations (13) and (15). Finally, differences in real GDP per capita determine the absolute differences in A_m (and A_s) across countries using equation (16).

5.2 Results

The Role of Correlated Distortions We start by reporting how variation in γ_i alone across countries affects average establishment size, sectoral productivity, and sectoral output. Table 10 reports the results of increases in γ across countries, from 0 in the benchmark economy to 0.9 in the most distorted economy. For these results, we assume that $\gamma_m = \gamma_s$, so that correlated distortions are the same across sectors within an economy but vary across economies. For instance, an increase in correlated distortions from 0 to 0.7—well within the range observed in the cross-country elasticities reported earlier—implies that average establishment size drops by 64 percent in both sectors: from 22 persons engaged to 8 in the manufacturing sector and from 4.8 persons engaged to 1.7 in the service sector. This range in establishment size corresponds well with the range reported earlier in the data across countries in the income distribution. Similarly, productivity in each sector drops by 41 percent, only half of which is the direct impact of misallocation. As a result of these effects, sectoral output drops by about 30 percent in each sector and a similar effect on aggregate output.

Table 10: MODEL RESULTS ACROSS CORRELATED DISTORTIONS γ

γ	Establishment Size (M)	Establishment Size (S)	Endogenous Productivity (Both)	Impact from Misallocation (M)	Impact from Misallocation (S)	Sectoral Output (M)	Sectoral Output (S)
0.0	22	4.8	1	1	1	1	1
0.1	17	3.8	0.92	1.00	1.00	0.99	0.99
0.3	12	2.7	0.80	0.96	0.96	0.93	0.93
0.5	9	2.1	0.70	0.90	0.91	0.82	0.84
0.7	8	1.7	0.59	0.81	0.86	0.67	0.71
0.9	7	1.5	0.43	0.72	0.82	0.46	0.53

Notes: Results of the model for variations in γ assuming $\gamma = \gamma_m = \gamma_s$. Entry costs and exogenous sector productivity are kept constant. Columns report equilibrium values for average establishment size in each sector, endogenous sectoral productivity, sectoral productivity from factor misallocation, and real sectoral output. Results in columns 4 through 8 are reported relative to the benchmark U.S. economy.

Average Establishment Size We now study the implications of our data on the productivity elasticity of distortions on average establishment size across sectors and countries. By construction, cross-country and sector variation in correlated distortions γ_i and entry costs c_e^i match average establishment sizes in all countries.[33] Since entry costs are derived as a residual, we are interested in the extent to which cross-country variation in γ_i can account for the variation in establishment sizes in the data. Figure 5 reports the average establishment size

[33]Recall from equation (12) that average establishment size depends on both correlated distortions and entry costs.

in the data and the model when only γ_i varies for each sector. We note that differences in γ_i in poorer countries vis a vis the benchmark economy generate large differences in average size both in manufacturing and services. For example, the average γ_i across developing countries in our data is 0.78 manufacturing and 0.87 in services. This implies an average size of 8 in manufacturing and 1.5 in services. In the data, the average across countries with γ's close to these averages is an average size of 9 persons engaged in manufacturing and 3.2 in services.[34] It is also clear that there is substantial variation in establishment size across countries that is not accounted for by differences in correlated distortions, but this unexplained variation is not systematically related to the level of development. Indeed, Figure 6 suggests that entry costs are no higher in poorer economies. If anything, they are lower. While this may seem surprising, this is consistent with smaller establishments in poor economies. These results are also consistent with the evidence in Bento (2018a), who uses a model of multi-product firms to decompose observed barriers to competition into product-specific barriers and firm-specific entry costs. He finds entry costs hardly vary across countries and are slightly lower in poorer countries.

Sectoral Productivity The elements affecting sectoral productivity in the model, as specified in equation (13) are: exogenous variation in sector productivity A_i, endogenous entry productivity, establishment size, and misallocation. Figure 7 shows the variation in sector productivity that arises due to variation in γ. As with establishment size, the model generates a substantial drop in sectoral productivity in distorted economies which is about half of that observed in the data. Of the total impact of correlated distortions on sectoral productivity, Table 10 suggests about half of the impact comes from misallocation across establishments and half from the distortionary effects on entry and investment.

Structural Change and Aggregate Productivity Figure 8 illustrates the variation in the share of manufacturing relative to services generated by the model with only variation in γ_i

[34]These averages are calculated over countries with $\gamma_m \in (0.73, 0.83)$ and $\gamma_s \in (0.82, 0.92)$.

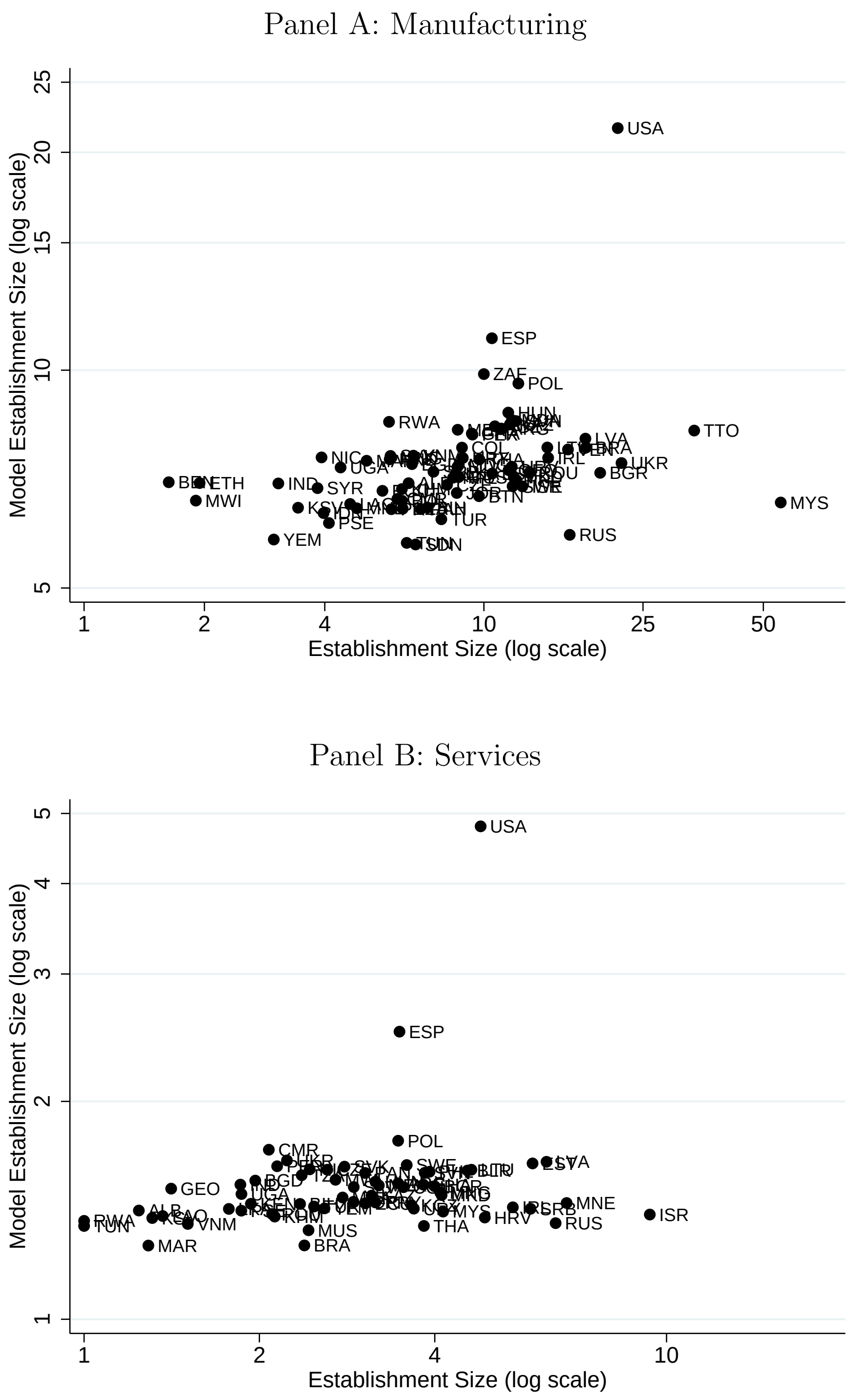
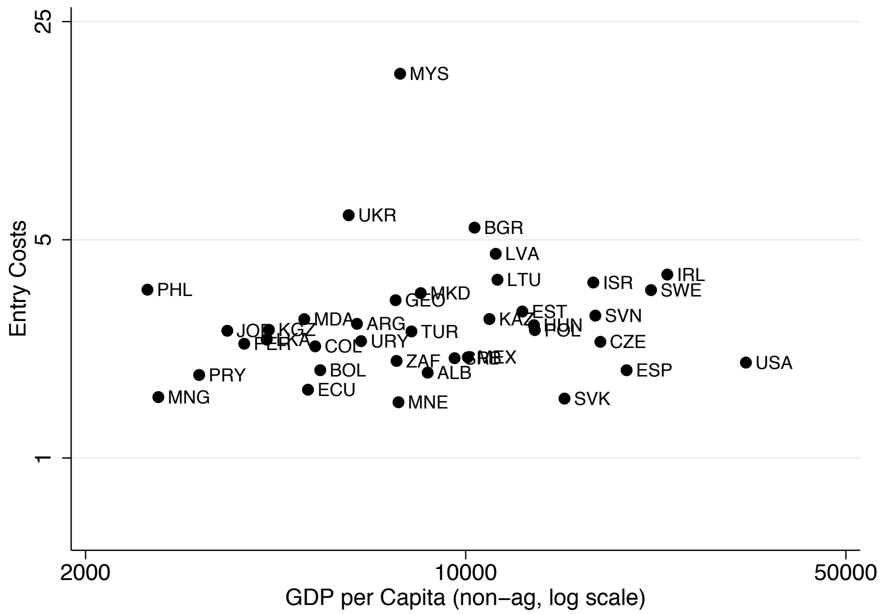


Figure 5: Average Establishment Size, Model vs. Data

Panel A: Manufacturing



Panel B: Services

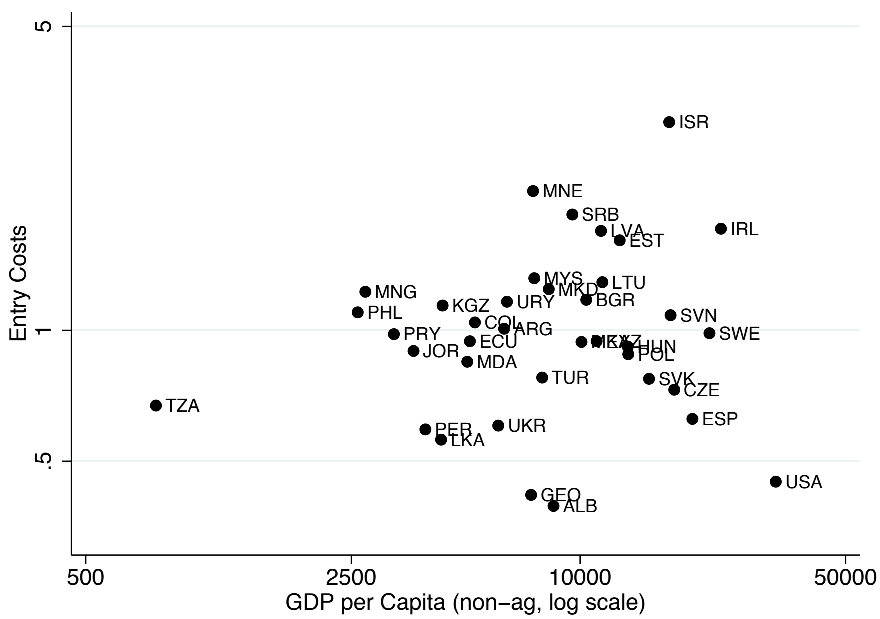
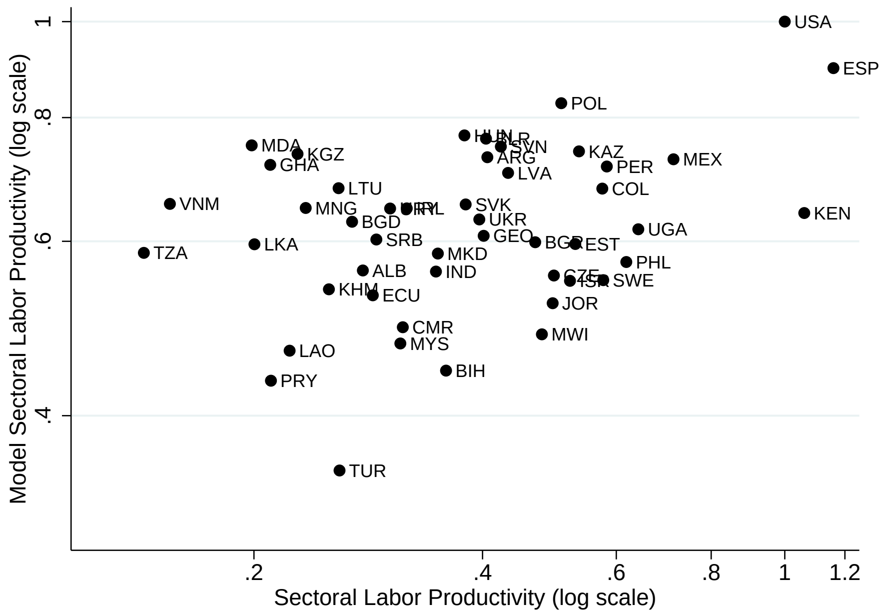


Figure 6: Entry Costs and GDP per Capita

Panel A: Manufacturing



Panel B: Services

Figure 7: Sectoral Labor Productivity, Model vs. Data

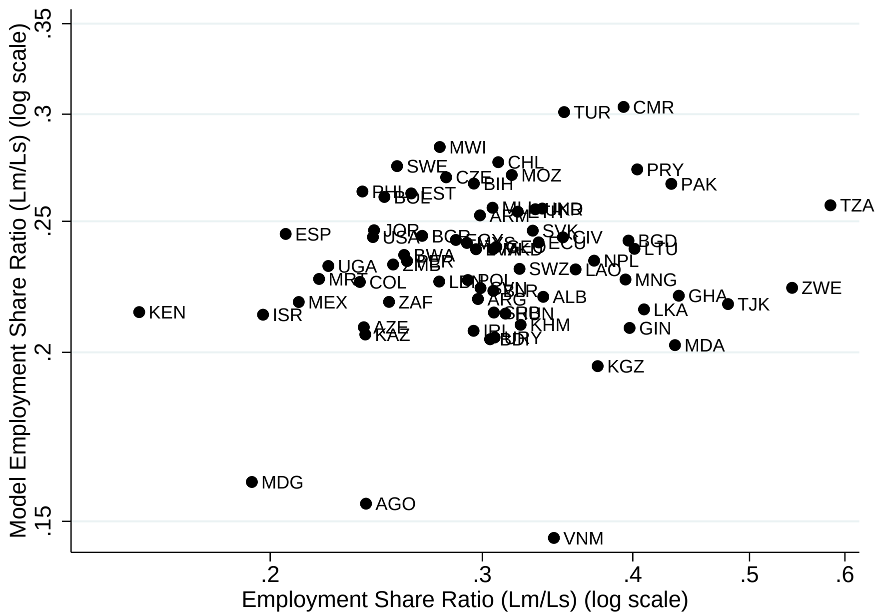


Figure 8: Ratio of Employment across Sectors (Lm/Ls), Model vs. Data

across countries and the variation in the data. The model captures about half the variation in the ranges of employment across sectors but we note, as discussed earlier, that there is not a systematic relationship between sectoral shares of manufacturing and services in the non-agricultural sector and GDP per capita.

Finally, we can isolate the effect of differences in observed γ_i across sectors and countries on GDP per capita by applying each economy's γ_i to our benchmark U.S. economy, while keeping A_i and c_e^i constant at U.S. levels in each sector. Figure 9 reports the results. The model implies substantial variation in non-agricultural GDP per capita and this variation represents almost 50 percent of the variation observed in the data ($\approx \log(3)/\log(10)$).

6 Conclusion

We construct and document comprehensive and comparable data for the average size of establishments across countries within both manufacturing and services. We report a strong positive

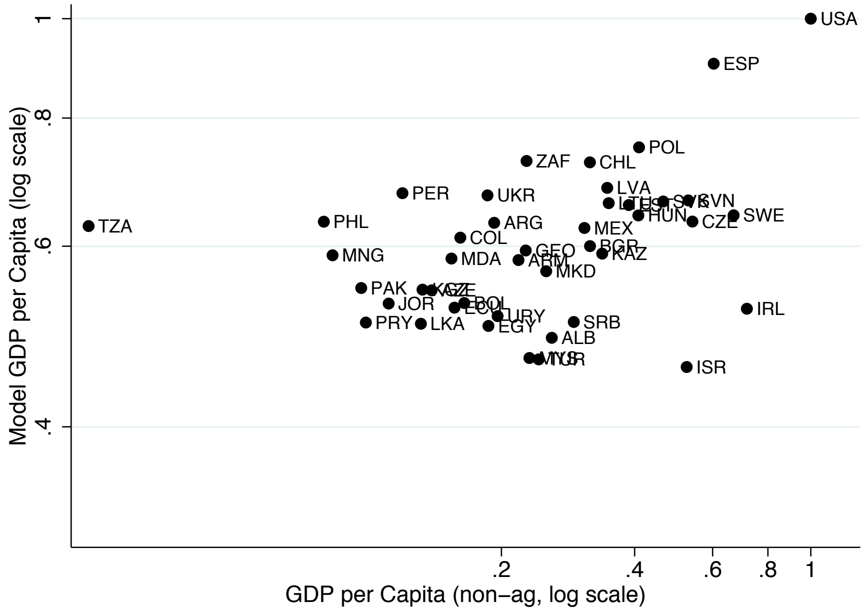


Figure 9: GDP per Capita: Model vs. Data

relationship between establishment sizes and GDP per capita and a remarkably similar income elasticity of average establishment size in manufacturing and services. We also construct and document data for the productivity elasticity of distortions across a large set of countries for manufacturing and service sectors showing a strong negative relationship between this elasticity and GDP per capita in both sectors.

Relating the average size data to several prominent theories of development and TFP, we find that measures of correlated distortions are robustly related to average size and, in particular to the ratio of average size across sectors. We then consider an otherwise standard model of production heterogeneity with endogenous entry and productivity investment to assess the quantitative impact of policy distortions on establishment size, establishment productivity, and aggregate output. In the theory, entry and productivity investment by establishments is affected by the productivity elasticity of distortions. In a calibrated version of the model to U.S. data, increasing the productivity elasticity of distortions from zero to 0.7—a level observed for many developing countries in our data—reduces average establishment size in each sector by 64 percent, sector productivity by 41 percent, and output per worker by 54 percent in manufacturing and 47 percent in services.

Our results suggest a strong link between policy distortions (misallocation) and technology across countries that substantially contributes to differences in establishment size and output per capita across countries. Our evidence on distortions and average establishment sizes across sectors and countries suggest similar impacts of policy distortions on manufacturing and services industries. We also uncover substantial variation in establishment sizes across service industries, which we think is an important issue that warrants further work.

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Appendix

A Service Sector Establishment Size Data

Table 11 lists each country in the final service sector dataset, the number of industries for which data is available, and the sources from which data has been collected. See Bento and Restuccia (2017) for the corresponding table for manufacturing.

Table 11: List of Countries and Sources

Country	Code	Industries	Sources
Åland Islands	ALA	5	Statistics and Research Åland: Statistical Yearbook of Åland 2010 and www.asub.ax
Albania	ALB	6	Instituti i Statistikave: www.instat.gov.al/en/figures/statistical-databases.aspx
American Samoa	ASM	9	U.S. Census Bureau: U.S. Economic Census 2007
Andorra	AND	8	Departament d'Estadística: www.estadistica.ad
Anguilla	AIA	8	Anguilla Statistics Department: Abstract of Statistics 2000
Argentina	ARG	8	Instituto Nacional de Estadística y Censos: 2005 Economic Census
Aruba	ABW	8	Central Bureau of Statistics: Business Count 2003
Australia	AUS	9	Australian Bureau of Statistics: Counts of Australian Businesses 2007, Labour Force Surveys (Quarterly)
Austria	AUT	8	Statistik Austria: statcube.at
Bahrain	BHR	8	Kingdom of Bahrain Central Informatics Organization: Population, Housing, Buildings, Establishments and Agriculture Census
Bangladesh	BGD	9	Bangladesh Bureau of Statistics: Economic Census 2013
Belgium	BEL	7	OECD's SDBS Structural Business Statistics
Benin	BEN	9	Institut National de la Statistique et de l'Analyse Economique: General Census of Companies
Bosnia and Herzegovina	BIH	8	Institute for Statistics of FB&H: Statistical Yearbook 2008, Federation of Bosnia and Herzegovina in Figures 2011
Brazil	BRA	9	Brazilian Institute of Geography and Statistics: Cadastro Central de Empresas
Brunei	BRN	7	Department of Economic Planning and Development: Brunei Darussalam Statistical Yearbook 2010
Bulgaria	BGR	7	Eurostat
Cambodia	KHM	8	National Institute of Statistics: Economic Census 2011
Cameroon	CMR	5	Institut National de la Statistique du Cameroun: Recensement Général des Entreprises 2009
Canada	CAN	9	Statistics Canada: CANSIM
Cape Verde	CPV	9	Instituto Nacional de Estatística: Estatísticas de Empresas - Inquérito Anual ás Empresas 2013

Table 11: List of Countries and Sources

Country	Code	Industries	Sources
Chad	TCD	8	Institut National de la Statistique, des Etudes Economiques et Démographiques: Recensement Général des Entreprises
Columbia	COL	4	Departamento Administrativo Nacional de Estadística: www.dane.gov.co
Croatia	CRV	8	Eurostat and Central Bureau of Statistics: Statistical Yearbook 2009
Cyprus	CYP	7	Eurostat
Czech Republic	CZE	7	OECD's SDBS Structural Business Statistics
Denmark	DNK	7	OECD's SDBS Structural Business Statistics
Dominican Republic	DNK	7	Oficina Nacional de Estadística: Registro Nacional de Establecimientos
Ecuador	ECU	8	Instituto Nacional Estadística y Censos: National Economic Census 2010
El Salvador	SLV	9	Ministerio de Economica: Tomo I de los VII Censos Económicos Nacionales 2005
Estonia	EST	7	Statistics Estonia: Statistical Yearbook 2011 and pub.stat.ee
Faroe Islands	FRO	7	Statistics Faroe Islands: www.hagstova.fo
Finland	FIN	7	Statistics Finland: www.stat.fi
France	FRA	8	Eurostat
French Guiana	GUF	7	Institut national de la statistique et des études économiques: L'Enquête Annuelle d'Entreprise en Guyane en 2006 and Tableaux Économiques Régionaux Guyane
French Polynesia	PYF	8	Institut de la Statistique de la Polynésie Française: www.ispf.pf and Les entreprises polynésiennes en 2010
FYR Macedonia	MKD	7	State Statistical Office: www.stat.gov.mk
Georgia	GEO	8	National Statistics Office of Georgia: Statistical Yearbooks 2008 and www.geostat.ge
Germany	DEU	7	Eurostat and OECD's SDBS Structural Business Statistics
Ghana	GHA	9	Ghana Statistical Service: Integrated Business Establishment Survey 2014
Greece	GRC	7	Eurostat and OECD's SDBS Structural Business Statistics
Greenland	GRL	7	Statistics Greenland: bank.stat.gl
Guadeloupe	GLP	4	Institut national de la statistique et des études économiques: Caractéristiques des entreprises et établissements and L'Enquête Annuelle d'Entreprise: Les Services en Guadeloupe en 2006
Guam	GUM	9	U.S. Census Bureau: U.S. Economic Census 2007
Guernsey	GGY	9	States of Guernsey: Facts and Figures 2016: Supplementary Data
Hong Kong	HKG	8	Census and Statistics Department: 2007 Annual Surveys of Wholesale, Retail, Import and Export Trades, Restaurants, Hotels, Building, Construction, Real Estate Sectors, Transport and Related Services, Storage, Communication, Banking, Financing, Insurance, and Business Services

Table 11: List of Countries and Sources

Country	Code	Industries	Sources
Hungary	HUN	7	Eurostat and OECD's SDBS Structural Business Statistics
Iceland	ISL	8	Eurostat
India	IND	8	Central Statistics Office: 2005 Economic Census
Iran	IRN	4	Statistical Centre of Iran: Statistical Yearbook 1389
Ireland	IRL	8	Central Statistics Office: www.cso.ie
Israel	ISR	9	Eurostat and OECD's SDBS Structural Business Statistics
Italy	ITA	7	Eurostat and OECD's SDBS Structural Business Statistics
Japan	JPN	8	Statistics Japan: Establishment and Enterprise Census 2006
Jordan	JOR	8	Department of Statistics: www.dos.gov.jo
Kazakhstan	KAZ	9	Committee on Statistics: www.stat.gov.kz
Kenya	KEN	9	National Bureau of Statistics: Micro, Small and Medium Enterprises (MSMEs) Basic Report 2016 and Statistical Abstract 2016
Korea	KOR	8	Statistics Korea: Censuses on Establishments 2007
Kosovo	UVK	6	Statistical Agency of Kosovo: Statistical Register of Business
Kuwait	KWT	8	Central Statistical Bureau: Annual Surveys of Establishments 2007
Kyrgyzstan	KGZ	9	National Statistical Committee of Kyrgyz Republic: stat.kg
Laos	LAO	9	Lao Statistics Bureau: Economic Census 2006
Latvia	LVA	7	Eurostat
Liechtenstein	LIE	9	Statistical Office: Statistical Yearbooks 2014
Lithuania	LTU	7	Eurostat
Luxembourg	LUX	7	Eurostat
Macau	MAC	5	Statistics and Census Service: Statistical Yearbook 2007
Malawi	MWI	4	National Statistical Office: Statistical Yearbook 2005
Malaysia	MYS	3	Department of Statistics Malaysia: Census of Distributive Trade in 2014
Maldives	MDV	8	Department of National Planning: Economic Survey 2007/2008
Malta	MLT	7	Eurostat
Mauritius	MUS	8	Statistics Mauritius: Censuses of Economic Activity 2002, 2007, Phases I and II
Mexico	MEX	9	Instituto Nacional de Estadstica y Geografía: Censos Economicos 2009
Micronesia	FSM	8	Division of Statistics: www.sboc.fm
Moldova	MDA	8	Statistica Moldovei: www.statistica.md
Monaco	MCO	3	Monaco Statistics: Commerce Observatory 2008
Mongolia	MNG	8	National Statistical Office: Mongolian Statistical Yearbook 2011
Montenegro	MNE	8	Statistical Office of Montenegro: www.monstat.org and Statistical Yearbook 2010
Morocco	MAR	9	Haut-Commissariat au Plan du Maroc: 2001-2 Economic Census
Netherlands	NLD	7	Eurostat

Table 11: List of Countries and Sources

Country	Code	Industries	Sources
New Caledonia	NCL	8	Institut de la Statistique et des Etudes Economique: www.isee.nc
New Zealand	NZL	9	Statistics New Zealand: www.stats.govt.nz
Nicaragua	NIC	9	Instituto Nacional de Información de Desarrollo: Urban Economic Census
Norfolk Island	NFK	2	Australian Business Statistics: www.ausstats.abs.gov.au
Northern Mariana Islands	MNP	9	U.S. Census Bureau: U.S. Economic Census 2007
Norway	NOR	7	Eurostat
Palau	PLW	8	Office of Planning and Statistics: 2012 Economic Indicators
Palestinian Territories	PSE	9	Palestinian Central Bureau of Statistics: Establishment Censuses 2007
Panama	PAN	8	Instituto Nacional de Estadística y Censo: Economic Census 2012
Paraguay	PRY	9	Direccin General de Estadística, Encuestas y Censos: National Economic Census 2011
Peru	PER	9	Instituto Nacional de Estadística e Informática: IV Censo National Economico 2008
Philippines	PHL	9	National Statistics Office: NSO's 2012 List of Establishments
Poland	POL	7	Eurostat
Portugal	PRT	7	Eurostat
Puerto Rico	PRI	9	U.S. Census Bureau: U.S. Economic Census 2007
Qatar	QAT	9	Ministry of Development Planning and Statistics: Establishment Censuses 2008
Romania	ROU	7	National Institute of Statistics: Statistical Yearbooks 2007-2009
Russia	RUS	7	Federal State Statistics Service: Industry of Russia 2009, and Small and Medium Businesses in Russia 2015
Rwanda	RWA	9	National Institute of Statistics of Rwanda: Establishment Census 2011
Samoa	WSM	8	Bureau of Statistics: www.sbs.gov.ws
San Marino	SMR	8	Ufficio Informatica, Tecnologia, Dati e Statistica: Il Bilancio di Previsione per l?Esercizio Finanziario 2010
São Tomé and Príncipe	STP	7	Instituto Nacional de Estatísticas de São Tomé e Príncipe: Business Statistics 2007
Saudi Arabia	SAU	9	Central Department of Statistics and Information: 2010 Economic Census
Serbia	SRB	8	Republika Srpska Institute of Statistics: Statistical Yearbook of Republika Srpska 2012
Sierra Leone	SLE	8	Statistics Sierra Leone: Report of the Census of Business Establishments 2005
Singapore	SGP	8	Department of Statistics Singapore: Yearbook of Statistics 2012, 2014, 2015

Table 11: List of Countries and Sources

Country	Code	Industries	Sources
Slovak Republic	SVK	9	Statistical Office of the Slovak Republic: slovak.statistics.sk and Statistical Yearbook 2013
Slovenia	SVN	7	Eurostat
Spain	ESP	7	Eurostat
Sri Lanka	LKA	7	Department of Census and Statistics - Sri Lanka: Census of Trade and Services 2003-2006
Svalbard	SJM	9	Statistics Norway: www.ssb.no
Sweden	SWE	7	Eurostat
Switzerland	CHE	5	Swiss Statistics: www.bfs.admin.ch/bfs/portal/en/index.html
Taiwan	TWN	9	National Statistics: Industry, Commerce and Service Censuses 2006
Thailand	THA	7	National Statistical Office: Business Trade and Industrial Census 2008 and 2012
Tunisia	TUN	8	Institut National de la Statistique: www.ins.nat.tn
Turkey	TUR	8	OECD's SDBS Structural Business Statistics
Uganda	UGA	8	Uganda Bureau of Statistics: Report on the Census of Business Establishments 2010/2011
Ukraine	UKR	9	State Statistics Service of Ukraine: www.ukrstat.gov.ua
United Arab Emirates	ARE	6	National Bureau of Statistics: www.uaestatistics.gov.ae
United Kingdom	GBR	7	Eurostat
United States	USA	9	U.S. Census Bureau: U.S. Economic Census 2007
Uruguay	URY	8	Instituto Nacional de Estadística: Directory of Companies and Establishments
U.S. Virgin Islands	VIR	9	U.S. Census Bureau: U.S. Economic Census 2007
Venezuela	VEN	8	Instituto Nacional de Estadística: IV Censo Económico
Vietnam	VNM	9	General Statistics Office: Survey of Business Establishments Producing Non-Agricultural Individual Period 2005-2015
Yemen	YEM	8	Central Statistical Organization: Services Survey Report 2004, Transport and Telecom Survey Report 2003, and Internal Trade Survey Results 2004