Evaluating the Effects of Entry Regulations and Firing Costs on International Income Differences*

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Abstract

This paper analyzes the effects of entry regulations and firing costs on cross-country differences in income and productivity. We construct a general equilibrium industry-dynamics model and quantitatively evaluate it using the cross-country data on entry costs and firing costs. Entry costs lower overall productivity in an economy by keeping low-productivity establishments in operation and making the establishment size inefficiently large. Firing costs lower productivity by reducing the reallocation of labor from low-productivity establishments to high-productivity establishments. The linear regression of the data on the model prediction accounts for 27% of the cross-sectional variation in total factor productivity. Moving the level of entry costs and firing costs from the U.S. level to that of the average of low income countries (countries with a Gross National Income below 2% of the U.S. level) reduces TFP by 27% in the model without capital, and by 34% in the model with capital and capital adjustment costs.

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JEL Classifications: D24, E23, J65, L11, O11

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1 Introduction

Continuous reallocation is an important feature of well-functioning market economies. Production resources are reallocated from low-productivity production units to high-productivity production units, promoting aggregate productivity growth. Recent empirical studies document that this process is quantitatively very important. For example, using the Census of Manufactures data, Foster, Haltiwanger, and Krizan (2001, Table 8.4) attribute about half of the multifactor productivity growth in the U.S. manufacturing sector during 1977-1987 to the reallocation of production resources across plants. In particular, 26% of the total productivity growth is due to the entry and exit of plants during this 10 year period.[1] In a cross-country context, therefore, barriers to factor reallocations can have a significant effect on the level of aggregate total factor productivity (TFP) in each country.

In this paper, we make an attempt to quantify the effects of barriers to factor reallocations on aggregate TFP. Many researchers attribute the main cause of the large differences in per-capita income across countries to differences in TFP.[2] One important research question is how institutional and policy differences contribute to the TFP differences.

Our main purpose and contribution here is that we provide a *benchmark* regarding how particular barriers to factor reallocations can affect the measured aggregate TFP. Our paper provides a benchmark in two respects. First, we use a version of arguably the most commonly used industry dynamics model by Hopenhayn (1992) and Hopenhayn and Rogerson (1993). Second, we consider two frictions that directly impact the reallocation process and are also quantitatively measurable: entry costs and firing costs. In addition, by considering both frictions at the same time, we provide a quantitative sense of how these two frictions work together. Although our model is very simple and the frictions that we highlight are limited for the purpose of capturing all of the mechanisms that hinder reallocations in reality, we

[1] The data frequency of the Census of Manufactures is every 5 years. Foster, Haltiwanger, and Krizan (2001, Table 8.7) also report decomposition results for each 5-year interval (1977-1982, 1982-1987, and 1987-1992) separately.

[2] See, for example, Klenow and Rodríguez-Clare (1997).

believe that starting with a simple benchmark would benefit a future study with a richer environment.

The following is the summary of our quantitative results. The linear regression of the data on the model prediction accounts for 27% of the cross-sectional variation in total factor productivity. Moving the level of entry costs and firing costs from the U.S. level to that of the average of low income countries (countries with a Gross National Income below 2% of the U.S. level) reduces TFP by 27% in the model without capital and by 34% in the model with capital and capital adjustment costs. In the model without capital, moving only the entry costs from the U.S. level to the level of the average of low income countries reduces TFP by 21% and moving only the firing costs reduces TFP by 7%. Because $(1 - 0.27)$ is larger but very close to $(1 - 0.21) \times (1 - 0.07)$, it turns out that these two effects essentially do not interact—they neither amplify nor mitigate each other's effect.

One important aspect of our analysis is that we exclusively focus on the *formal* sector. It is well known that in many poor countries there is a large informal sector.[3] Studies such as Erickson (2004) and D'Erasmo and Moscoso Boedo (2011) take the existence of an informal sector seriously. Some aspects of our measure of barriers—for example, the cost of legal registration—do not apply to firms in the informal sector. We focus on the formal sector not because we believe that the informal sector is unimportant, but because we view this analysis as a benchmark. The mechanisms that we highlight are: (i) high entry costs reduce entry, reduce exits of inefficient establishments, and allow establishments to operate at an inefficiently large scale; and (ii) high firing costs hinder the reallocation of labor from low-productive establishments to high-productive establishments. To the extent that the existence of an informal sector alleviates the effect of these barriers, one can view that our results are providing an *upper bound for these particular mechanisms.*

Another important aspect is that we are focusing only on these two particular frictions. One can expect that incorporating additional types of frictions would further account for the

[3]See, for example, La Porta and Shleifer (2008).

poor performance of those countries in which the economy tends to be heavily regulated.

Several recent studies, such as Hsieh and Klenow (2009) and Restuccia and Rogerson (2008), analyze how the costs of reallocation affect aggregate TFP. Here we consider a benchmark model with directly measured barriers for many countries. In these past studies, the barriers are hypothetically given in the model (Restuccia and Rogerson) or measured as "wedges" compared to the frictionless allocation (Hsieh and Klenow).[4] We utilize the direct measures of these barriers from the World Bank's "Doing Business" dataset. We take the entry and exit process seriously by building a model with endogenous entry and exit, whereas the aforementioned two studies assume exogenous entry and exit. We focus on the problem of labor reallocation, in contrast to Hsieh and Klenow (2009) who mainly analyze capital reallocation. Labor income accounts for a larger portion of aggregate income, implying that labor reallocation can potentially be very important.

A few other recent papers also examine the effect of entry costs in industry-dynamics models using the "Doing Business" dataset. Poschke (2010) considers a model with technology choice upon entry and with product differentiation. He shows that a model with technology choice and product differentiation exhibits a large effect of entry costs on productivity. His analysis focuses on the productivity differences between the U.S. and Europe. In contrast, our paper analyzes all of the countries in the dataset, and in particular focuses on low-income countries. Barseghyan and DiCecio (2011) analyze a model similar to ours, but there are differences in the details of the model setups, and they employ a different calibration strategy. We consider endogenous labor supply while in their model labor supply is fixed. They do not analyze the effect of capital adjustment costs. Both Poschke (2010) and Barseghyan and DiCecio (2011) consider only entry costs and do not consider firing costs. We consider both costs simultaneously and find that these two essentially do not interact. Barseghyan (2006) also constructs a model to analyze the effects of entry costs on TFP. Ebell and Haefke (2009) and Felbermayr and Plat (2007) analyze the effect of entry costs on

[4] Alfaro, Charlton, and Kanczuk (2008) conduct an analysis similar to Hsieh and Klenow (2009) for a large set of countries.

the unemployment rate using the “Doing Business” dataset. Marimon and Quadrini (2006) also analyze the effect of entry costs on cross-country income differences. Their mechanism is very different from ours—they emphasize that with a lower entry cost, a new firm demands a higher level of human capital, and this in turn encourages the innovators to accumulate more human capital. Messina (2006) analyzes the effect of entry costs on the structural transformation in developed countries.

The analysis of entry costs is motivated by a large literature in development economics that emphasizes the importance of entry regulations. For example, Djankov, La Porta, Lopez-de-Silanes, and Shleifer (2002), using an earlier version of the “Doing Business” dataset, describe how entry regulations (taking many forms) differ across countries. Starting from de Soto’s (1989, 2000) influential studies, it has been argued that these differences in entry costs have important implications for cross-country differences in income and productivity. However, economists have not reached a consensus on the quantitative importance of these costs. We construct a general equilibrium model of industry dynamics based on Hopenhayn and Rogerson (1993) to quantitatively evaluate the effect of these costs in a standard framework of industry dynamics.[5]

In our analysis, we consider two different types of entry costs. First is the monetary cost of starting up: this includes the monetary cost of legal registration, which was 31 times the monthly minimum wage in de Soto’s (2000) garment workshop. Second is the time cost of red tape—in many developing countries it takes time to legally start up a new operation. De Soto (2000) documents that, for example, registering a small garment workshop with one worker in Peru took 289 days with six hours of work every day. This is a substantial amount of labor cost. In the benchmark Hopenhayn and Rogerson (1993) model, entry costs lower overall productivity of the economy by allowing low-productivity establishments to survive and making the establishment size inefficiently large. We show that this effect can

[5]Note that de Soto (1989, 2000) emphasizes the importance of legal institutions and the enforcement of property rights, rather than the particular mechanism that we highlight. Models with informality, such as Erickson (2004) and D’Erasmo and Moscoso Boedo (2011), are a more appropriate framework for analyzing de Soto’s hypothesis.

be quantitatively substantial in countries with extremely high entry costs.

In most of this paper, we consider an establishment to be the fundamental production unit. This is a natural choice given the description of the entry cost data (the entry cost has to be paid for each location of production). Many empirical studies in development economics, some of which we compare with our model in Section 6, deal with firm-level data. The distinction between an establishment and a firm can be an important distinction to make when the ownership structure is crucial –for example, in the analysis of credit constraints. In our analysis, the ownership structure is not essential, and we focus on the establishment level.

The effects of firing costs have been extensively analyzed in the macroeconomics literature, starting with Bentolila and Bertola (1990) and Hopenhayn and Rogerson (1993). The previous analyses, however, have almost exclusively focused on comparisons of U.S. and European labor markets. Also in contrast to our motivation, the past analyses emphasize the employment effect of firing costs rather than the productivity effects.[6] Lagos (2006) points out that labor market policies such as firing costs can affect measured aggregate TFP. Samaniego (2006b) considers the effect of firing costs on technology adoption and Poschke (2009) analyzes the effect on aggregate productivity growth. Poschke (2009) utilizes an endogenous growth model, focusing on the effect on growth. In contrast, we aim at quantifying the level effect. His experiment is only for the case of a firing cost equivalent to one year's worth of wages, while we consider various levels of firing costs that appear in the "Doing Business" dataset. Koeniger and Prat (2007) analyzes the effect of firing costs (in addition to entry costs and fixed costs) on firm and job turnover in a matching model of unemployment. In our dataset (which is described in Section 2), we see that several poor countries have extremely large firing costs. This suggests that firing costs may be an important source of low TFP in some countries. In our model, firing costs lower productivity by reducing the reallocation of labor from low-productivity establishments to high-productivity establishments. We show

[6] Hopenhayn and Rogerson (1993) do analyze the productivity effects, although their emphasis is more on the employment effect. In footnote 25, we compare our results with theirs in detail.

that a large firing cost can have a quantitatively significant effect on TFP.

For most of this paper, we assume that labor is the only input of production. In Section 5, we briefly analyze a model with capital stock, which is similar to Veracierto (2001). There, the role of capital adjustment costs is highlighted.

Our analysis provides a strong prediction regarding the establishment size distribution. In Section 6, we compare our prediction to studies of firm size distribution. As we discuss there, the results are mixed. This calls for further investigation into the study of firm size and establishment size distribution in developing countries.

The paper is organized as follows. In the next section, we describe the "Doing Business" dataset and provide an overview of the entry costs and firing costs across countries. Section 3 sets up the model and calibrates it to the U.S. data as the benchmark. Section 4 describes the results. In Section 5, we extend the model to include the capital stock. Section 6 compares the model outcome to the cross-country micro-level data. Section 7 concludes.

2 Entry frictions and firing costs around the world

We utilize the "Doing Business" dataset (2008) created by the World Bank, which measures different aspects of business regulations across countries. The information collected covers a wide variety of regulations having to do with opening, operating, and closing a business. It measures the cost in resources, time, and the number of procedures related to these regulations. An attractive aspect of this database is its international comparability, achieved by reporting the cost of the opening, operating and closing of a standardized firm, which is set up in the same way across countries.

Figure 1 plots our entry cost measures against Gross National Income (GNI) per capita.[7][8] The GNI per capita is scaled relative to the U.S. GNI per capita. The entry cost consists of two parts: the cost of starting (incorporating) a business (left panels) and the cost of

[7] All variables in this section are log-transformed, except for the firing cost measures. Firing cost measures are presented in levels because they include many zeros. The lines in the figures are OLS regression lines.

[8] In all of the figures in this section, the tail of the distribution is cut out for the presentation. They are included when the OLS regression is performed.

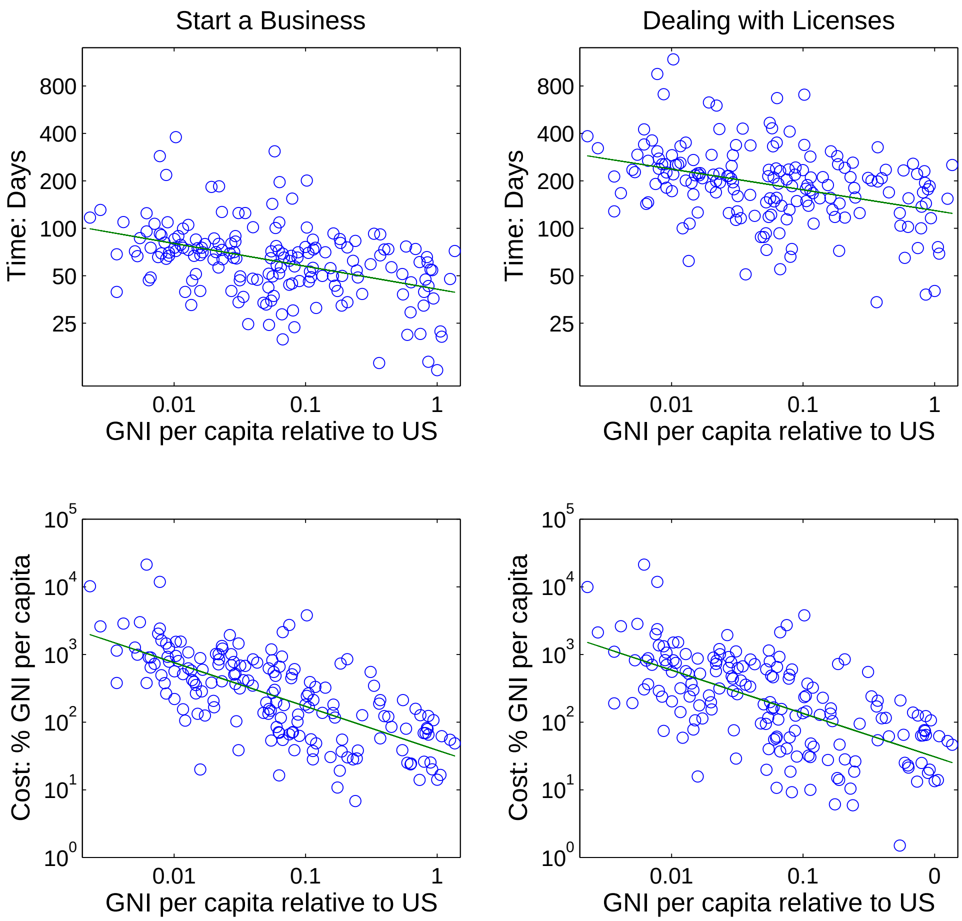

Figure 1: Time and cost of starting a business and dealing with licenses, against Gross National Income (GNI) per capita. The left panels plot the cost of starting a business, and the right panels plot the cost of dealing with licenses. The upper panels are the time spent (days) and the lower panels are the monetary cost (as a % of GNI per capita). Source: Doing Business 2008, World Bank.

dealing with licenses (right panels). Each cost consists of two parts: the time spent (upper panel) and the monetary cost (lower panel). The monetary cost is represented as a percent of GNI per capita. It can be seen from the figure that all entry cost measures have negative correlations with GNI per capita.

We consider the "time" for starting a business and dealing with licenses to be an important part of the entry cost. As is discussed in de Soto's (2000) garment workshop experiment, the "time" is not just a waiting time but rather the firm has to actively work on the procedures. When we calculate the correlation coefficient between the sum of the "time" measures of the entry cost and the number of procedures necessary to start a business (which is also available in the "Doing Business" dataset), it turns out to be 0.4.[9] This positive relationship suggests that the "time" reflects the amount of work that is required. In the quantitative model, we assume that the period "one day" here implies the cost equivalent to the labor cost (wage) of one worker for one day.

There is substantial variation in these entry cost measures across countries. In the U.S., the monetary cost of starting is effectively zero (0.7% of per capita GNI). In some countries, this cost is considerable: in Sierra Leone the cost is over 1,000% of per capita GNI, and in Congo and Liberia it is close to 500% of per capita GNI. In the U.S., the time period for starting a business is six days. In some countries, it can take a very long time: in Suriname, it takes more than two years to complete the process of starting a business.

The cost of obtaining a license—which is the cost of setting up a warehouse, including obtaining the necessary licenses and permits, completing required notifications and inspections, and obtaining utility connections—also displays large differences. The monetary cost is negligible in the U.S., at 13% of per capita income. This has even larger variation than the start-up cost: in Liberia it costs more than 600 times per capita income, and in Zimbabwe it costs more than 100 times per capita income. The time cost is also substantial in some countries. In Haiti, it takes more than 1,000 days.

[9]This is statistically significant at the 95% level.

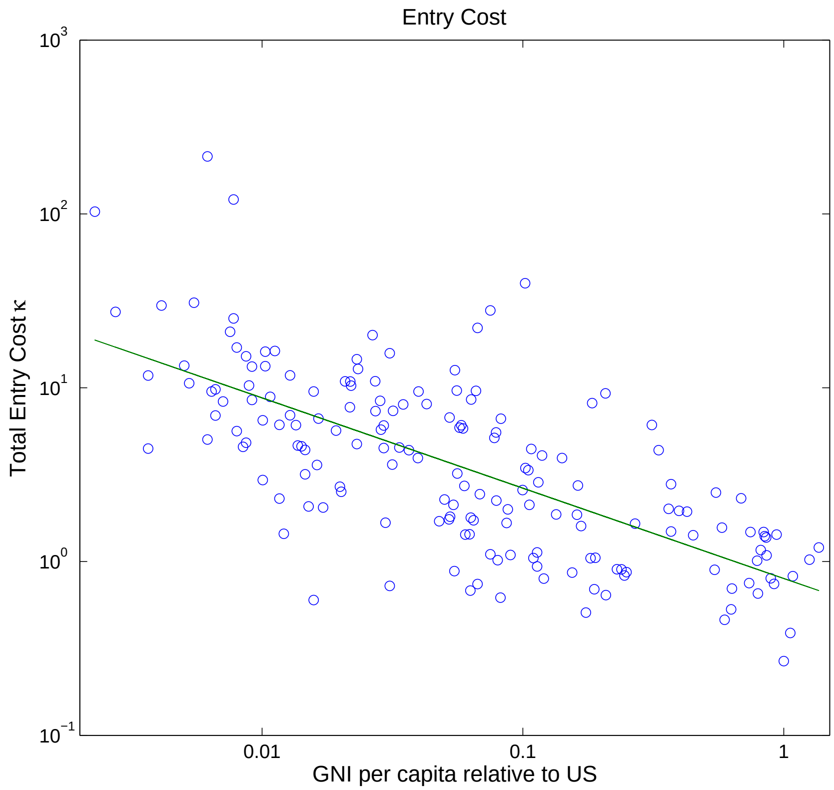

Figure 2: Total entry cost in wage units, against GNI per capita. Source: Doing Business 2008, World Bank.

In Figure 2, we add up (after adjusting for units) all of the costs in Figure 1. This is the entry cost measured in units of annual wages. Here, the monetary costs are interpreted as percent of the wage rather than percent of the GNI per capita (as in the actual data), so it deviates from the actual cost by as much as the wage deviates from the GNI per capita. However, we believe that this is a fairly good approximation.[10] We denote this as κ in the following. Therefore, the entry cost is κw, where w is the annual wage.

For the firing costs, we use the direct measure that is included in the "Doing Business"

[10] In the model's calibration, the benchmark value of total earnings per period is 0.6 times the wage (in the benchmark, the level of employment is set at 0.6). Because the benchmark labor share is 0.64, output (which corresponds to the GNI per capita here) equals total earnings times 1/0.64, which is about 94% of the wage. Therefore, the wage and GNI per capita in the benchmark case can be viewed as approximately the same.

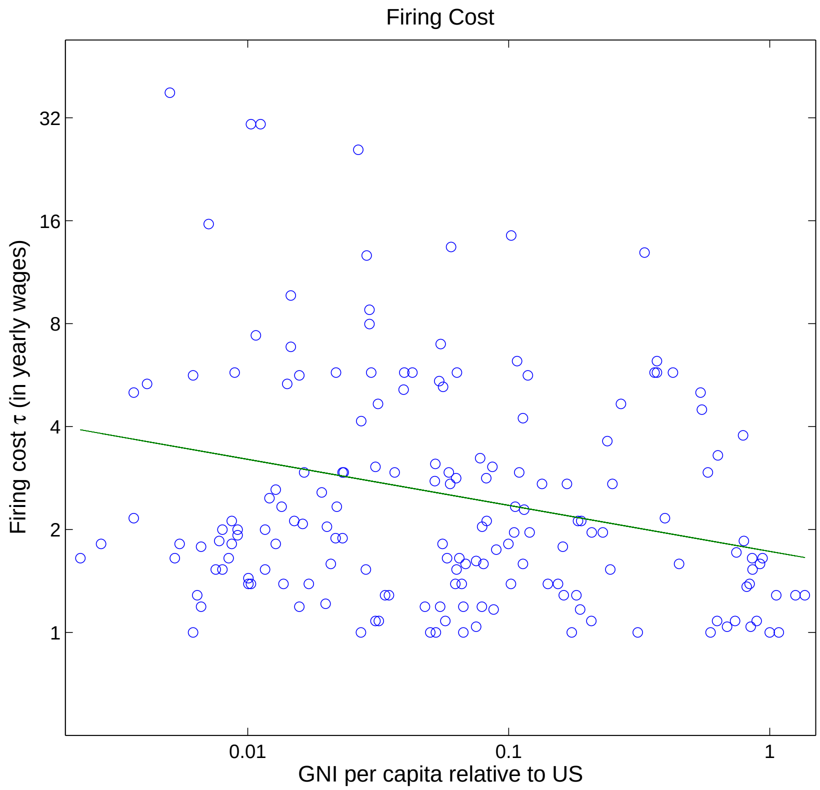

Figure 3: Firing costs in yearly wages, against GNI per capita. Source: Doing Business 2008, World Bank.

dataset. This measures the cost of advance notice requirements, severance payments, and penalties due when terminating a worker. It is measured in units of weekly wages in the dataset, and we convert it to annual wages. We denote it τ. Firing costs (τ) also have an interesting pattern when plotted against income. That relationship is shown in Figure 3. The correlation of τ and per capita GNI is negative. At an extreme, it is not possible to fire workers in Bolivia and Venezuela. Firing a worker requires more than eight years of wages in Zimbabwe. In the U.S., the firing cost is zero. The median value of τ is 0.7 and the mean value is 1.0.[11]

[11]In calculating the mean value, we replaced "not possible to fire" with $\tau = 10$.

Finally, the correlation coefficient between $\log(\kappa)$ and τ is 0.31.[12] This implies that, although the correlation is positive, a high-κ country does not necessarily correspond to a high-τ country.

3 Model

In this section, we describe our quantitative model, which is based on Hopenhayn and Rogerson (1993). Given that our aim is to provide the benchmark result for a standard model of industry dynamics, we construct the model as closely as possible to the setting of Hopenhayn and Rogerson (1993). One big departure is the introduction of the random fixed operating cost, which is necessary in order to match the exit pattern seen in the data.

Time is discrete, with one period set to be one year. There are two kinds of entities in the economy: establishments and consumers. The establishments produce the consumption goods for the consumers. The consumers supply labor (the only production factor in this section) to the establishments. The consumers also own the establishments and receive profits. We consider this to be our benchmark and we compute the outcome country by country. We add capital to the model in Section 5. There, due to computational complexity, we will consider a "representative country" in each income group.

3.1 Establishments

Here we describe the behavior of the establishments. First, we describe the timing of incumbent establishments. Then, we describe the entrants' timing.

An incumbent establishment begins period t with the individual state (s_{t-1}, n_{t-1}). Where s_{t-1} is the productivity level of the establishment in period $t-1$, and n_{t-1} is its employment level in period $t-1$. The value function of an establishment at this stage is denoted as $W(s_{t-1}, n_{t-1})$.

First, the incumbent draws the fixed cost that is required for continuing the operation,

[12] This is statistically significant at the 95% level.

c_f. It is assumed that c_f is an i.i.d. random variable with the distribution $\xi(c_f)$.[13] After observing c_f, the establishment decides whether to exit. We assume that there is a firing cost (in consumption goods) of the amount $\tau w \max\langle 0, n_{t-1} - n_t\rangle$ (where $\tau \geq 0$ and w is the annual wage rate), so an exiting establishment has to pay $\tau w n_{t-1}$ for adjusting employment down to zero.[14] The firing cost $\tau \geq 0$ corresponds to the the measure described in Section 2. As in Hopenhayn and Rogerson (1993), we treat the firing cost as a tax that is transferred back to the consumers in a lump-sum manner. Below we consider only the steady state of the aggregate economy, and thus w is a constant value over time.

If the establishment decides to stay, it pays c_f and observes the current period's productivity s_t. The distribution of s_t given s_{t-1} is expressed by the conditional distribution $\eta(s_t|s_{t-1})$. The value function at this point is denoted as $V(s_t, n_{t-1})$. Then the establishment decides the amount of employment in the current period, n_t, and produces. The production function is $f(n_t, s_t)$, which is increasing and concave in n_t.

To enter, the entrant has to pay $c_e + \kappa w$ units of consumption goods as an entry cost, where c_e can be interpreted as the sunk investment. The part of the entry cost captured by $\kappa \geq 0$, which is completely wasted, measures the additional entry barrier in units of annual per capita wages—this is the entry cost measured in Section 2.[15][16] Next, the entrant draws the initial productivity s_t from the distribution $\nu(s_t)$. Then it decides the employment n_t and produces.

The incumbent solves the Bellman equation

$$W(s_{t-1}, n_{t-1}) = \int \max \left\langle \int V(s_t, n_{t-1}) d\eta(s_t|s_{t-1}) - c_f, -\tau w n_{t-1} \right\rangle d\xi(c_f),$$

[13]This type of randomness is necessary in order to obtain a realistic exit pattern. See the discussions in Lee and Mukoyama (2008). Samaniego (2006a) made this point earlier. Samaniego (2008) also considers a similar setup.

[14]A more realistic treatment would be to consider different firing costs for short- and long-term workers.

[15]An alternative view of the entry cost is that it is a pure transfer, as in the "grabbing hand" theory of Shleifer and Vishny (1998). Our assumption that κ is a pure waste is another sense in which the model provides an upper bound on the effect of κ.

[16]Note that the wage is here only for measurement purposes—the additional cost is κw units of the *consumption good*, not κ units of labor.

where

$$V(s_t, n_{t-1}) = \max_{n_t} \left\{ f(s_t, n_t) - wn_t - \tau w \max\langle 0, n_{t-1} - n_t \rangle + \beta W(s_t, n_t) \right\}.$$

Here, β is the discount factor. Let the decision rule of n_t be $n_t = \phi(s_t, n_{t-1})$. Also define the decision rule for exiting as $\chi(s_{t-1}, n_{t-1}, c_f)$: $\chi(s_{t-1}, n_{t-1}, c_f) = 1$ when exiting and $\chi(s_{t-1}, n_{t-1}, c_f) = 0$ when staying.

The entrant's value V^e is calculated as

$$V^e = \int V(s', 0) d\nu(s').$$

We assume free entry; therefore,

$$V^e = c_e + \kappa w \tag{1}$$

holds in an equilibrium with positive entry.

3.2 Consumers

The representative consumer maximizes expected utility:

$$\mathbf{U} = E\left[\sum_{t=0}^{\infty} \beta^t [\log(C_t) - AL_t]\right],$$

where $E[\cdot]$ is the expectation operator, C_t is consumption, and L_t is labor supply. The consumer's discount factor is the same as the establishment's discount factor in the steady state where C_t is constant. This form of the utility function is extensively used in the Real Business Cycles literature with indivisible labor (e.g. Hansen (1985) and Rogerson (1988)), and is also used by Hopenhayn and Rogerson (1993). We focus on the steady state below, so we express both by β. A is a constant parameter. The budget constraint is

$$C_t = w_t L_t + \Pi_t + T_t, \tag{2}$$

where w_t is the wage at time t, Π_t is the total profit, and T_t is the lump-sum rebate of the firing tax. The first-order condition is

$$\frac{w_t}{C_t} = A. \tag{3}$$

3.3 General equilibrium

From here, we will focus on the stationary equilibrium where all of the aggregate variables are constant. Total profit is given by

$$\Pi_t = Y_t - w_t L_t - F_t - T_t - M_t(c_e + \kappa w_t), \tag{4}$$

where M_t denotes the mass of entrants at period t, and Y_t is total output, given by

$$Y_t = \int f(s_t, \phi(s_t, n_{t-1}))d\mu(s_t, n_{t-1}),$$

and $\mu(s_t, n_{t-1})$ is the (stationary) distribution of establishments that are going to produce at period t (including the new entrants, whose $n_{t-1} = 0$). T_t is the total firing tax, which is the sum of the firing tax paid by the establishments which produce in period t, T_t^p, and the firing tax paid by the establishments which exit at the beginning of period t, T_t^x. T_t^p can be calculated as:

$$T_t^p = \int \tau w_t \max\langle 0, n_{t-1} - \phi(s_t, n_{t-1})\rangle d\mu(s_t, n_{t-1}).$$

From stationarity, T_t^x can be computed as

$$T_t^x = T_{t+1}^x = \int \int \chi(s_t, \phi(s_t, n_{t-1}), c_f) d\xi(c_f) \tau w_{t+1} \phi(s_t, n_{t-1}) d\mu(s_t, n_{t-1}).$$

M_t is the total number of entrants. The total operation cost F_t can be calculated by

$$F_t = F_{t+1} = \int \int c_f(1 - \chi(s_t, \phi(s_t, n_{t-1}), c_f)) d\xi(c_f) d\mu(s_t, n_{t-1}).$$

From (2), (3), and (4),

$$\frac{w_t}{Y_t - F_t - M_t(c_e + \kappa w_t)} = A \tag{5}$$

holds. The total labor demand is

$$L_t = \int \phi(s_t, n_{t-1}) d\mu(s_t, n_{t-1}). \tag{6}$$

Because the establishment's decision rules are only affected by w_t, we can solve the Bellman equations and obtain the equilibrium w_t from (1). Given the decision rules obtained from the optimization, we can calculate $\mu(s_t, n_{t-1})$ for any given number of entering establishments. Let $\mu^1(s_t, n_{t-1})$ be the stationary distribution when the mass of entrants is assumed to be one. Then, $\mu(s_t, n_{t-1}) = M_t \mu^1(s_t, n_{t-1})$ holds. Therefore, given the decision rules and w_t, (5) pins down the equilibrium value of M_t.

3.4 Calibration

We set one period as one year. We calibrate the model to the establishment-level data in the United States. The data on the establishment distribution is taken from the Statistics of U.S. Businesses (SUSB) dataset, and the table is calculated from the 2003–2004 data.[17] Our strategy is to match the model's moments without entry regulation ($\kappa = 0$) or firing tax ($\tau = 0$) to the U.S. data and use that as the benchmark.[18] Then we will experiment with the effects of the entry regulation and firing tax.

We assume that the production function is

$$f(s_t, n_t) = s_t n_t^{\theta}.$$

As in the standard real business cycle literature, we set $\beta = 0.94$ and $\theta = 0.64$. Following Hopenhayn and Rogerson (1993), we normalize the benchmark value of $w = 1$. This is achieved by setting c_e so that the free-entry condition (1) holds under $w = 1$. This procedure yields $c_e = 36.19$. We also set the benchmark value of $L = 0.6$ in the benchmark without entry costs or firing costs, following Hopenhayn and Rogerson (1993). This value is motivated by the employment rate in the U.S. Because L is an endogenous variable, this is done by first finding an M that satisfies (6) with $L = 0.6$, and then setting A so that (5) holds with this M. This yields $A = 1.36$.

For the stochastic process of s_t, we take the following strategy. First, we discretize the domain of s_t. In particular, we pick the grids of s_t so that the optimal level of employment

[17] See `http://www.census.gov/csd/susb/` for more details about this dataset. The cross-sectional tables below are created as a customized table.

[18] In the "Doing Business" dataset, the U.S. entry cost is not exactly zero ($\kappa = 0.27$). Because this is a negligibly small amount, we regard this as zero in this section. In Section 6, we measure all of the κ's as the difference from the U.S. value of κ.

	Data	Model
$1-4$	72.04	72.04
$5-9$	14.03	14.03
$10-19$	7.32	7.32
$20-49$	4.27	4.27
$50-99$	1.37	1.37
$100-249$	0.72	0.72
$250-499$	0.16	0.16
$500-999$	0.06	0.06
$1000-$	0.04	0.03

Table 1: Size distribution of entrants (%), U.S. data and model

(without firing tax) at each s_t corresponds to the 1/4, 1/2, and 3/4 point of the cells that are used to tabulate the SUSB dataset.[19] (For the largest cell, we pick $n_t = 1500$.) Then we try to match the model's outcome to the cross-sectional properties of the data. The entrant's distribution $\nu(s)$ is set so that the size distribution of the entrants matches the data, as in Table 1.[20]

We calibrate the distribution of c_f, $\xi(c_f)$, to match the exit rates in the data, shown in Table 2. We set $\xi(0) = 0.8$ and $\xi(\bar{c}_f) = 0.045$. The value for $\bar{c}_f$ is very large and this, in effect, acts as the exogenous part of the decision to exit. The rest of the probability is uniformly distributed across $[0, 45]$. As we can see from Table 2, this procedure yields a reasonable match with the exit pattern observed in the data.

For the transition probabilities of s_t, we first assume that it follows an AR(1) process:

$$\log(s_{t+1}) = a + \rho \log(s_t) + \epsilon_{t+1}, \tag{7}$$

where $\epsilon_{t+1} \sim N(0, \sigma^2)$. Then, we approximate this on the s grids, in a similar manner to Tauchen (1986). We set $\rho = 0.97$. This value is motivated by the highly persistent employment process in the U.S. manufacturing sector, as documented in Lee and Mukoyama

[19]We make sure that we have enough grids on n, so that the optimal choice is not constrained by the discreteness of the grid.

[20]Within the cell, we distribute the probabilities equally. The "1000−" cell does not match the data because of rounding (the data cell numbers add up to 100.1%).

	Data	Model
$1-4$	14.88	16.45
$5-9$	6.72	9.84
$10-19$	5.57	4.50
$20-49$	4.91	4.50
$50-99$	4.58	4.50
$100-249$	4.16	4.50
$250-499$	3.90	4.50
$500-999$	4.25	4.50
$1000-$	4.21	4.50

Table 2: Exit rates (%), U.S. data and model

(2008).[21] The value of σ is set so that the total job creation rate (JC rate) becomes similar to the data.[22] We set $\sigma = 0.11$. the parameter a is set to 0.035 and this brings the average size of all establishments close to what is seen in the data. Table 3 summarizes the statistics from the U.S. data and the model. Table 4 depicts the size distribution of establishments in the U.S. data and in the model.[23] Given that the calibration target is only the average value (and initial distribution), this shows a very good match.

As described in Section 2, the cross-country comparison of entry regulations and firing costs comes from the "Doing Business" dataset. The values of κ and τ in the data are described in Section 2.

4 Results

This section describes the results from our experiment. First we change the entry cost parameter (κ) and the firing cost parameter (τ) one by one, and then we vary them both at the same time.

[21] As Hopenhayn and Rogerson (1993) show, the employment process and the productivity process have a one-to-one mapping when there are no frictions.

[22] Becasue our model is in a steady state, the total job destruction rate (JD rate) is equal to the total job creation rate (JC rate).

[23] The average size of opening establishments does not exactly match because we do not have any information on how the sizes are distributed within a cell. We put equal masses at the 1/4, 1/2, and 3/4 points of the cell, but in the data it is likely that the within-cell distribution is not uniform.

	Data	Model
Avg size of total establishments	17.6	16.7
Avg size of opening establishments	8.3	9.2
Avg size of closing establishments	9.0	9.0
Entry rate (%)	11.6	10.7
Exit rate (%)	10.2	10.7
Total JC rate (%)	15.8	16.6
JC rate by opening establishments (%)	5.5	5.9
Total JD rate (%)	14.4	16.6
JD rate by closing establishments (%)	5.2	5.8

Table 3: Summary statistics

	Data	Model
$1-4$	48.52	42.14
$5-9$	21.52	22.70
$10-19$	14.24	17.57
$20-49$	9.77	11.44
$50-99$	3.32	4.19
$100-249$	1.87	1.52
$250-499$	0.47	0.32
$500-999$	0.17	0.08
$1000-$	0.10	0.02

Table 4: Size distribution of establishments, in the U.S. data and the model (%)

	$\kappa = 3.4$	$\kappa = 29.9$
Y	0.96	0.78
L	1.00	0.98
w	0.96	0.79
Y/L	0.96	0.79
Y/L^{θ}	0.96	0.79
C	0.96	0.79
Avg size of total establishments	1.11	1.77
Avg size of opening establishments	1.12	1.90
Avg size of closing establishments	1.13	2.08
Entry/Exit rate	0.96	0.75
Total JC rate	0.99	0.95
JC rate by opening establishments	0.97	0.80
Total JD rate	0.99	0.95
JD rate by closing establishments	0.98	0.87

Table 5: Summary statistics for $\kappa = 3.4$ and $\kappa = 29.9$. All values are relative to the benchmark.

$\log(s_t)$ below	1.0	1.5	2.0	2.5	3.0
Benchmark	42.1%	82.4%	95.9%	99.6%	100.0%
$\kappa = 29.9$	39.6%	83.9%	96.5%	99.7%	100.0%

Table 6: Cumulative distribution: the fraction of establishments with a $\log(s_t)$ below each specified value.

4.1 Entry costs

First, we analyze the effect of κ. As we saw in Section 2, there is substantial variation in κ. The smallest is seen in the U.S. (0.3) and the largest in Liberia (616.8). There are 32 countries with $\kappa > 10$ and there are 29 countries with $\kappa < 1$.

Now we analyze how the model behaves with $\kappa = 3.4$ and $\kappa = 29.9$, compared to the benchmark. The entry cost represented by $\kappa = 3.4$ corresponds to the median value of κ in the data and $\kappa = 29.9$ is the average value for low income countries with GNI per capita of less than 2% of the U.S. level. Table 5 summarizes the results. We can see that larger entry costs translate into lower productivity through lower entry and exit rates and larger

$\log(s_t)$	0.52	0.77	0.92	1.22	1.48
Benchmark	5.0	10.0	15.0	35.0	45.0
$\kappa = 29.9$	10.0	17.5	27.5	45.0	45.0

Table 7: Exit thresholds: the maximum values of c_f (on the grid) with which the establishment decides to stay in operation at each value of $\log(s_t)$. (The values $\log(s_t)$ are not evenly spaced because we picked the values on the grid.)

establishment sizes. The labor supply is similar across different κ. From (1), it is clear that a higher κ implies a higher V^e, which implies that the equilibrium wage is lower. There are two channels through which a lower wage translates into lower productivity. First, it reduces the incentive to exit and keeps a low-productivity establishment in operation. This can be seen from Table 6 and Table 7. Table 6 is the cumulative distribution of $\log(s_t)$ in the steady state for the benchmark ($\kappa = 0$) and $\kappa = 29.9$. That is, it shows the fraction of the establishments with a $\log(s_t)$ below the specified values in the table. There are two opposing effects—in addition to the aforementioned effect, a high κ implies a low entry rate. This improves the productivity distribution because entrants are less productive than the average establishment. However, for most of the distribution (except for the very lowest part), the benchmark dominates the $\kappa = 29.9$ distribution. Second, each establishment hires more workers. Because there are decreasing returns to scale in labor, labor productivity decreases as each establishment with a given s hires more workers. Quantitatively, the combined effect is substantial—the TFP (Y/L^θ) is 21% lower when $\kappa = 29.9$. This means that in countries like Afghanistan ($\kappa = 214.1$), Burundi ($\kappa = 103.1$), Liberia ($\kappa = 616.8$), and Zimbabwe ($\kappa = 121.1$), entry costs have a significant effect on productivity.[24] Table 7 presents the exit thresholds for different s_t. These are the maximum values of c_f (on the grid) for which the establishment decides to continue operating. The exit threshold is higher for $\kappa = 29.9$, which implies that establishments are more likely to remain operating when $\kappa = 29.9$.

[24]Barseghyan's (2008) regression results indicate that an increase in entry costs of 80% of annual income per capita lowers output per worker by 29%. In our model, imposing an additional entry cost of as much as one year's wage ($\kappa = 1$) decreases Y/L by 1%. This points to a possibility that our model does not capture some channels through which the entry cost affects productivity.

	$\tau = 0.7$	$\tau = 1.2$
Y	0.92	0.89
L	0.95	0.94
w	0.93	0.90
Y/L	0.97	0.95
Y/L^θ	0.95	0.93
C	0.93	0.90
Avg size of total establishments	1.06	1.09
Avg size of opening establishments	0.81	0.77
Avg size of closing establishments	1.09	1.15
Entry/Exit rate	0.94	0.89
Total JC rate	0.54	0.47
JC rate by opening establishments	0.72	0.64
Total JD rate	0.54	0.47
JD rate by closing establishments	0.97	0.94

Table 8: Summary statistics for $\tau = 0.7$ and $\tau = 1.2$. All values are relative to the benchmark.

Another way of looking at a high κ is that it is acting as an investment tax. The entry cost c_e can be interpreted as a sunk investment in equipment and the structure of the establishment. Increasing κ taxes this investment behavior and reduces the output-labor ratio.

4.2 Firing costs

Next we analyze firing costs. In Section 2, we saw that this cost also exhibits a lot of variation. In the U.S., the cost is zero. In 63 countries, more than one year's worth of wages has to be paid to fire a worker. In 15 countries, it is more than two years. In Bolivia and Venezuela, it is not possible to fire workers. In Zimbabwe, firing a worker requires more than eight years of wages as the firing cost.

Table 8 summarizes the results of the experiment with $\tau = 0.7$ and $\tau = 1.2$.[25] The

[25] Hopenhayn and Rogerson (1993) also consider the effect of a firing cost. Their results (their Table 3) indicate that average productivity falls by 2% and output falls by 5% when a firing tax that is equivalent to one year's wage is imposed. When the same amount of firing tax is imposed, our model predicts about a 4% decline in average productivity and a 10% decline in output. This difference in results is due to the difference in calibration—in particular, in our model one period is one year and in their model one period is five years.

parameter $\tau = 0.7$ corresponds to the median value in the data and $\tau = 1.2$ corresponds to the average value for the low income countries. Here, productivity is lower largely due to the lack of reallocation of workers from unproductive establishments to productive establishments. The correlation coefficient between $\log(s_t)$ and $\log(n_t)$ is 1.00 when $\tau = 0$, and it drops to 0.95 when $\tau = 1.2$. Job creation and job destruction are substantially lower relative to the benchmark.

Interestingly, the size of an opening establishment is smaller with a larger τ, despite a lower wage. The establishments are forward-looking, and they avoid expanding because they would have to pay the firing tax when they shrink again.

Another interesting observation is that L changes substantially with the firing cost. In this model, the wage w is determined by the free-entry condition (1), and therefore reflects the future profit opportunities for an *entering* establishment. Thus, the substitution effect for the consumer, which works through the change in the wage, reacts to the entering establishment's future profits. That is, when the opening establishment's future profits fall, the wage falls and the labor supply L declines. The wealth effect works in the opposite direction for L, and is related to the productivity of the *average* establishment. Here, the entering establishments face a larger effect of the firing tax than an average establishment, because the entering establishments are relatively less productive and therefore more likely to exit in the near future. Because they have to pay the firing tax when they exit, they are more heavily taxed than an average establishment. Therefore, the substitution effect prevails in determining L. For the same reason, the exit rate (and therefore the entry rate also) reacts substantially to the firing tax—it taxes the act of exiting.

To see this, in Table 9 we alternatively assume that the exiting establishments are not subject to the firing cost. There, L slightly increases with τ from $\tau = 0.7$ to $\tau = 1.2$ and

Thus, it is possible that our establishments adjust employment more frequently and pay the firing tax more often. Veracierto (2001) also observed that the period length matters. Additionally, in their calibration, an entrant is much smaller than incumbents, compared to our calibration. Therefore, their establishments spend more time expanding, during which they do not pay the firing tax. The difference in size comes from the fact that they calibrate the model using a dataset from the U.S. manufacturing sector, whereas our calibration is based on all sectors in the U.S. economy.

	$\tau = 0.7$	$\tau = 1.2$
Y	0.96	0.95
L	0.99	1.00
w	0.97	0.96
Y/L	0.97	0.95
Y/L^θ	0.97	0.95
C	0.97	0.96
Avg size of total establishments	1.06	1.10
Avg size of opening establishments	0.83	0.81
Avg size of closing establishments	1.11	1.19
Entry/Exit rate	1.00	1.09
Total JC rate	0.55	0.49
JC rate by opening establishments	0.79	0.74
Total JD rate	0.55	0.49
JD rate by closing establishments	1.05	1.09

Table 9: Summary statistics for $\tau = 0.7$ and $\tau = 1.2$, when $\tau = 0$ for exiting establishments. All values are relative to the benchmark.

the entry/exit rates increase with τ. Comparing this result with the baseline experiment (Table 8), we can see that, particularly for a large value of τ, the firing tax upon exiting is an important channel through which τ affects output and productivity in the baseline experiment.[26]

4.3 Both combined

In reality, both entry costs and firing costs are present, and both barriers tend to be higher in poor countries. Moreover, the combination of the barriers can generate a larger effect than a single barrier.

Table 10 repeats the same exercise as Table 5 and Table 8 with combined frictions. One can see how the effects are combined. For example, having both $\kappa = 29.9$ and $\tau = 1.2$ simultaneously would reduce the productivity Y/L^θ to 0.75 of the benchmark. This is smaller than when $\kappa = 29.9$ and $\tau = 0$ (0.79) or $\tau = 1.2$ and $\kappa = 0$ (0.93). The combined effect

[26]Samaniego (2006a) is the first to point out that the effect of a firing cost can differ considerably depending on whether the exiting establishments/firms have to pay the firing cost.

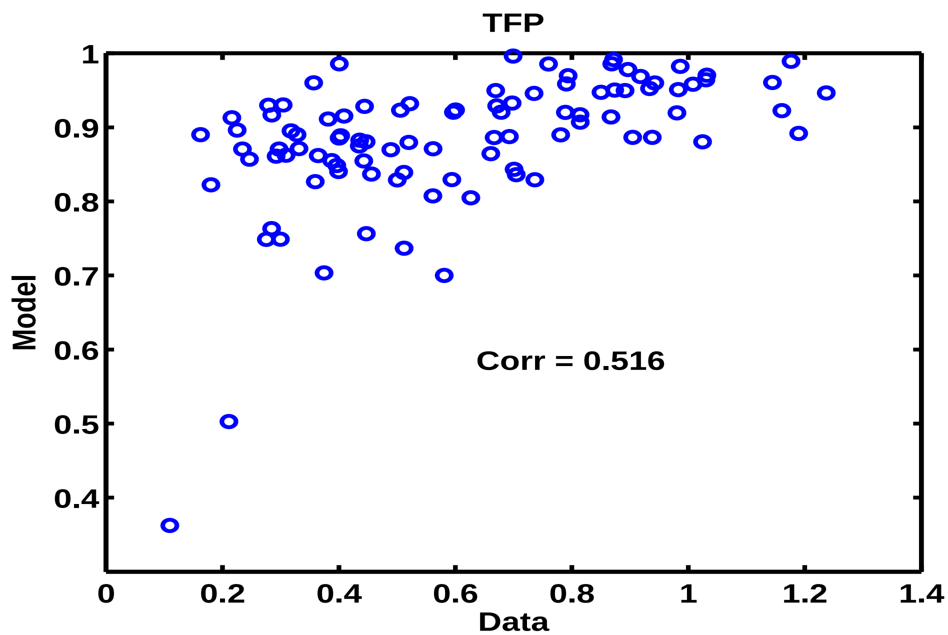

Figure 4: Total Factor Productivity in the model and the data.

	$\kappa = 3.4$ $\tau = 0.7$	$\kappa = 29.9$ $\tau = 1.2$
Y	0.89	0.71
L	0.95	0.92
w	0.90	0.73
Y/L	0.93	0.77
Y/L^{θ}	0.92	0.75
C	0.90	0.73
Avg size of total establishments	1.16	1.83
Avg size of opening establishments	0.90	1.40
Avg size of closing establishments	1.23	2.24
Entry/Exit rate	0.89	0.71
Total JC rate	0.53	0.44
JC rate by opening establishments	0.69	0.55
Total JD rate	0.53	0.44
JD rate by closing establishments	0.95	0.87

Table 10: Results for combinations of κ and τ. All values are relative to the benchmark.

is essentially multiplicative—$0.79 \times 0.93 = 0.73$ is only slightly smaller than 0.75. The two mechanisms do not either amplify or mitigate each other's effect.

In the following, we take the levels of τ and κ from the data and conduct the experiment for *all* countries. TFP in the data is constructed following and updating Hall and Jones (1999). We updated their measure of TFP using data from Heston, Summers, and Aten (2009) (output per worker and investment), Barro and Lee (2000) (average school attainment), and the United Nations (2008) (mining share of GDP). TFP is computed as follows:

$$TFP = \frac{Y}{K^{\alpha} H^{(1-\alpha)}}$$

where Y denotes aggregate output, K denotes aggregate capital, H denotes the labor aggregate adjusted for human capital, and α is the capital share.

Figure 4 compares the TFP from the model and the data. They are positively correlated, but TFP's dispersion in the data is substantially larger than in the model.

In Table 11 we compare the results of the model to the data by regressing the data on the model. The table reports the results in terms of TFP, output per worker, and entry rate for three cases (both κ and τ, κ only, and τ only).

If our model accounted perfectly for the data, we would have an R^2 of 1, an intercept of 0, and a slope of 1. From Table 11, we see that the model accounts for 27% of the variation in TFP (its R^2), while having a slope of 0.17 (not reported in the table), which is significantly different from zero. In terms of the other variables—output per worker and entry rate—the model explains 27% and 8%, respectively, of the data variation as shown by the different R^2 for the full model (with both frictions). In terms of the relative importance of frictions, it is clear that for almost every variable (except for the entry rate) the entry cost κ is more important than the firing cost τ in accounting for the variation in the data. Given that κ is the cost that is directly associated with entry, it is somewhat surprising that τ has a larger impact here in terms of R^2. In Table 11, we also report the results for the first two regressions excluding Zimbabwe and Liberia, which are clear outliers in Figure 4. The results are similar without these outliers.

		Complete Sample		No Outliers	
Variable	Frictions	R^2	N	R^2	N
TFP	(κ, τ)	0.27	97	0.26	95
	κ	0.25		0.34	
	τ	0.08		0.06	
Y/L	(κ, τ)	0.27	97	0.38	95
	κ	0.22		0.39	
	τ	0.11		0.11	
Entry Rate	(κ, τ)	0.08	73		
	κ	0.03			
	τ	0.07			

Table 11: The results from regressions comparing the data and model outcomes. The regression is: Data $= a_0 + a_1 \times$ Model $+ \epsilon$. N: sample size. The regressions without outliers do not use Zimbabwe and Liberia, clear outliers in Figure 4 in the bottom left corner. For the entry rate, Zimbabwe and Liberia are not in the sample for the original regression.

	U.S.	HIC	UMIC	LMIC	LIC
	$\kappa = 0.26$ $\tau = 0.0$	$\kappa = 1.4$ $\tau = 0.7$	$\kappa = 3.4$ $\tau = 0.8$	$\kappa = 6.5$ $\tau = 0.9$	$\kappa = 29.9$ $\tau = 1.2$
Y	1.00	0.90	0.87	0.85	0.71
L	0.60	0.57	0.57	0.57	0.55
w	1.00	0.92	0.89	0.86	0.73
TFP (Y/L^θ)	1.00	0.94	0.92	0.88	0.75
Avg size of total establishments	16.8	18.4	19.4	21.0	30.5
Avg size of opening establishments	9.3	7.8	8.2	8.8	13.0
Avg size of closing establishments	9.0	10.3	11.1	12.3	20.1
Entry/Exit rate (%)	10.7	9.8	9.5	9.1	7.6
Output per effective worker (data)	1	0.93	0.52	0.27	0.12
TFP (data)	1	0.93	0.72	0.47	0.33
Avg size of total establ. (data)	17.6	16	171.1	270	755.6
Entry rate (data)	0.13	0.10	0.08	0.08	0.07

Table 12: Results for various income levels (Y and TFP are relative to the U.S. levels)

Finally, we calculate the model's outcomes for the average values of different income groups, and for the U.S., in Table 12. We divide the countries into four income categories following the World Bank's categories—High Income Countries (HIC), Upper Middle Income Countries (UMIC), Lower Middle Income Countries (LMIC), and Low Income Countries (LIC). Roughly speaking, a country is classified as a HIC if its GNI per capita is higher than 25% of the U.S. GNI per capita, a UMIC if its GNI per capita falls between 8% and 25% of the U.S. level, a LMIC if its GNI per capita falls between 2% and 8% of the U.S. level, and a LIC if its GNI per capita is below 2% of the U.S. level. Then we calculate the average value of κ and τ for each income group, and run the experiments using these average values. Table 12 is presented here mainly for comparison to the results in the next section.

4.4 Understanding the interaction of the two frictions

In order to understand how the two frictions (the entry costs and the firing costs) interact, consider the following simple version of the model. A firm survives only for two periods after it enters. The firm's production function is sn^θ, where s is productivity, n is employment, and $\theta \in (0,1)$ is a parameter. Assume that the firm's productivity is only a function of age, $s = h$ at the first period ("young firm") and $s = \ell$ at the second period ("old firm"). Further assume that $h > \ell > 0$, and thus the firm's productivity declines over its age (maximizing the impact of the firing friction). There is no other operation cost other than the wage (w per unit of labor), and therefore there is no endogenous exit. There is free entry of firms with entry cost $c_e > 0$. The aggregate labor supply is fixed at one unit.

Since there is no endogenous exit, this model does not capture the effect of entry costs on aggregate productivity through the change in the productivity distribution. Here, the focus for the entry costs is the effect through the size of the operation. In order to analyze the effect of firing costs, we consider two economies. In Economy A, firms can hire and fire workers freely in each period. In Economy B, firms cannot fire workers at all due to very high firing costs. Since the firm's productivity falls over time, a firm wants to fire some workers at the end of its first period. When this is not possible, the firm takes it into account when it hires workers at the beginning of the first period.

We focus on the steady state where the wage is constant over time and assume that the firm's discount factor is one. In the steady state, the number of young firms and old firms in the economy is the same. In Economy A, a young firm solves the problem

$$\max_{n} \quad \pi_1 = hn^\theta - wn.$$

The optimal choice of n is

$$n = \theta^{\frac{1}{1-\theta}} h^{\frac{1}{1-\theta}} w^{-\frac{1}{1-\theta}},$$

output y_1 is

$$y_1 = hn^\theta = \theta^{\frac{\theta}{1-\theta}} h^{\frac{1}{1-\theta}} w^{-\frac{\theta}{1-\theta}},$$

and the profit is

$$\pi_1 = \Theta h^{\frac{1}{1-\theta}} w^{-\frac{\theta}{1-\theta}},$$

where $\Theta \equiv \theta^{\frac{\theta}{1-\theta}} - \theta^{\frac{1}{1-\theta}}$. We can similarly calculate the employment, the output, and the profit for an old firm by just replacing h by ℓ (we use the subscript 2 for an old firm). The present value of profit for a firm is therefore

$$V^e = \pi_1 + \pi_2 = \Theta\left(h^{\frac{1}{1-\theta}} + \ell^{\frac{1}{1-\theta}}\right) w^{-\frac{\theta}{1-\theta}}.$$

The free entry condition $V^e = c_e$ pins down the equilibrium wage as

$$w = \left[\Theta\left(h^{\frac{1}{1-\theta}} + \ell^{\frac{1}{1-\theta}}\right)\right]^{\frac{1-\theta}{\theta}} c_e^{-\frac{1-\theta}{\theta}}.$$

We can see that the wage is decreasing in the entry cost, as in our quantitative model. The steady state aggregate output with unit entry, Y_u, is

$$Y_u = y_1 + y_2 = \theta^{\frac{\theta}{1-\theta}} c_e \Theta^{-1}$$

and the aggregate labor demand with unit entry, L_u, is

$$L_u = \theta^{\frac{1}{1-\theta}}\left(h^{\frac{1}{1-\theta}} + \ell^{\frac{1}{1-\theta}}\right)^{-\frac{1-\theta}{\theta}} \Theta^{-\frac{1}{\theta}} c_e^{\frac{1}{\theta}}.$$

A large c_e implies a large Y_u. This is the effect of the entry costs on the operation size. Since a larger entry cost implies a lower wage, each firm operates with a larger size. Denoting the mass of entry as M, the labor market clearing condition $L_u M = 1$ pins down M:

$$M = \theta^{-\frac{1}{1-\theta}}\left(h^{\frac{1}{1-\theta}} + \ell^{\frac{1}{1-\theta}}\right)^{\frac{1-\theta}{\theta}} \Theta^{\frac{1}{\theta}} c_e^{-\frac{1}{\theta}}.$$

From this equation, it can be seen that a high entry cost reduces entry. The aggregate output (which is equal to aggregate labor productivity since the labor input is one) in Economy A is

$$Y^A = \theta^{-1}\left(h^{\frac{1}{1-\theta}} + \ell^{\frac{1}{1-\theta}}\right)^{\frac{1-\theta}{\theta}} \Theta^{\frac{1-\theta}{\theta}} c_e^{-\frac{1-\theta}{\theta}}. \tag{8}$$

The effect of the entry cost on the aggregate labor productivity is straightforward: a 1% increase in c_e reduces Y^A by $(1-\theta)/\theta$%.

Now consider the Economy B. An old firm wants to downsize but it can't, so it operates with the same size as it did when it was young. The firm foresees it at the first period, and therefore the problem for a young firm is now

$$\max_n \quad \pi_1 + \pi_2 = hn^\theta - wn + \ell n^\theta - wn = (h+\ell)n^\theta - 2wn.$$

The optimal choice of n is

$$n = \theta^{\frac{1}{1-\theta}} (h+\ell)^{\frac{1}{1-\theta}} (2w)^{-\frac{1}{1-\theta}}.$$

The present value of profit is

$$V^e = \pi_1 + \pi_2 = \Theta(h+\ell)^{\frac{1}{1-\theta}} (2w)^{-\frac{\theta}{1-\theta}}.$$

From the free entry condition, the wage is pinned down as

$$w = \frac{1}{2}\Theta^{\frac{1-\theta}{\theta}} (h+\ell)^{\frac{1}{\theta}} c_e^{-\frac{1-\theta}{\theta}}.$$

The steady state aggregate output with unit entry, Y_u, is

$$Y_u = y_1 + y_2 = \theta^{\frac{\theta}{1-\theta}} c_e \Theta^{-1}$$

and the aggregate labor demand with unit entry, L_u, is

$$L_u = 2\theta^{\frac{1}{1-\theta}} (h+\ell)^{-\frac{1}{\theta}} \Theta^{-\frac{1}{\theta}} c_e^{\frac{1}{\theta}}.$$

From the labor market clearing condition, the mass of entry M is

$$M = \frac{1}{2}\theta^{-\frac{1}{1-\theta}} (h+\ell)^{\frac{1}{\theta}} \Theta^{\frac{1}{\theta}} c_e^{-\frac{1}{\theta}}.$$

The aggregate output (and therefore the aggregate labor productivity) in Economy B is

$$Y^B = \frac{1}{2}\theta^{-1} (h+\ell)^{\frac{1}{\theta}} \Theta^{\frac{1-\theta}{\theta}} c_e^{-\frac{1-\theta}{\theta}}. \tag{9}$$

The effect of the entry cost on the aggregate labor productivity is the *same* as in Economy A: a 1% increase in c_e reduces Y^A by $(1-\theta)/\theta\%$. Thus, the effect of the entry costs does not interact with the firing costs. This is consistent with our quantitative finding.

Comparing Y^A and Y^B in (8) and (9), it can easily be shown that $Y^A > Y^B$: a high firing cost reduces productivity.[27] The reason that these two frictions do not interact is that they work with different margins.[28] A high entry cost reduces the efficiency of *all* firms by lowering

[27]This comparison ends up being the comparison between $(h^{\frac{1}{1-\theta}} + \ell^{\frac{1}{1-\theta}})/2$ and $((h+\ell)/2)^{\frac{1}{1-\theta}}$. The former is larger since the function $x^{\frac{1}{1-\theta}}$ is convex in x.

[28]This can also be seen from the fact that if $h = \ell$, the firing cost has no effect on productivity while the entry cost still have a negative impact.

the wage excessively. A high firing cost prevents the reallocation *between* firms with different levels of productivity—a high-productivity firm is excessively large and a low-productivity firm is excessively small due to the firing cost.

In the quantitative model, there is another important effect of the entry cost —that is, the change in the productivity distribution. This effect can potentially interact with the effect of the firing cost. The interaction may be positive or negative—if low productivity firms that do not exit because of a high entry cost hold too much labor due to a high firing cost, both effects enhance each other. At the same time, to the extent that the reduction of exit increases the persistence of the productivity process for incumbents, the effect of the firing cost would be attenuated. Our quantitative result, however, indicates that this interaction is quantitatively not very large in either direction in our model.

Looking at the results of the quantitative model country by country, we observe that the two frictions partially offset each other in high-friction countries such as Zimbabwe or Sri Lanka—the observed total effect in a model with both frictions is smaller by more than 10% than when compared to the sum of the individual effects. In some countries the joint effect is larger than the sum of individual effects, but in countries where the friction is substantial (the frictions decrease the output per worker by more than 5% of the U.S. level), the complementarity is not very strong.[29]

Note that the assumptions on endogenous entry and exit have an important impact on the joint effect of multiple frictions that include frictions on entry and exit. Our assumption about the timing of entry ensures that the distribution of productivity of the entrants is unaffected by frictions. Some other papers which add different features in the entry process generate large joint effects of multiple frictions. For example, Bergoeing, Loayza, and Piguillem (2011) obtain large complementary effects of different frictions through endogenous technology adoption at entry, and D'Erasmo, Moscoso Boedo, and Şenkal (2011) generate large complementary effects of different frictions through the introduction of human capital

[29]Larger complementary effects are observed for countries where the total effect is very small (mostly developed countries).

in an environment where there are financial frictions.

5 Incorporating capital stock

So far, we have considered a model in which output is produced with only labor input. In this section, we incorporate capital stock explicitly into the model. The firms own the capital stock k_t. The adjustment of the capital stock may be subject to adjustment costs, given by a function $\psi(k_{t+1}, k_t)$, except for the period in which the establishment enters. The investment is not perfectly reversible—the scrap value of capital when exiting is only a fraction $\gamma \in (0,1)$ of its original value. The establishment's production function is now $f(s,k,n) = sk^{\alpha}n^{\theta}$. Here, s is the idiosyncratic productivity level and n is labor input. We assume that $\alpha, \theta \in (0,1)$ and $\alpha + \theta < 1$ to maintain decreasing returns to scale with respect to k and n at the establishment level. The incumbent now solves the following Bellman equations

$$W(s_{t-1}, n_{t-1}, k_t) = \int \max \left\langle \int V(s_t, n_{t-1}, k_t) d\eta(s_t|s_{t-1}) - c_f, \gamma k_t - \tau w n_{t-1} \right\rangle d\xi(c_f)$$

and

$$\begin{aligned} & V(s_t, n_{t-1}, k_t) \\ = & \max_{n_t, k_{t+1}} \{ f(s_t, n_t, k_t) - w n_t - \tau w \max\langle 0, n_{t-1} - n_t \rangle - i_t - \psi(k_{t+1}, k_t) + \beta W(s_t, n_t, k_{t+1}) \} , \end{aligned}$$

with the standard law of motion for capital

$$k_{t+1} = (1-\delta) k_t + i_t,$$

where i_t is investment at time t. We assume free entry. After paying the entry cost, the entrant draws an initial productivity and invests in initial capital, which is not subject to adjustment costs. We assume that the entrant effectively draws $c_f = 0$ for the first period. The function $\psi(k_{t+1}, k_t)$ is assumed to be quadratic in the form $\lambda k(i/k)^2$, where the parameter λ determines the adjustment cost friction. We set the other parameters as: $\alpha = 0.27$, $\theta = 0.64$ and $\delta = 0.08$. The process for s_t is assumed to be AR(1), as in (7). In our benchmark case, we set the parameters for the adjustment cost, productivity persistence, and volatility parameters to those estimated by Cooper and Haltiwanger (2006) for the manufacturing sector in the U.S. In particular, we set $\lambda = 0.0975$, $\rho = 0.885$, and $\sigma^2 = 0.235$. The scrap value of capital is calibrated to 40% ($\gamma = 0.4$), as estimated by Ramey and Shapiro (2001). The long-term mean of productivity, a in (7), is set so that the average size of the incumbent firm from the model matches that in the data, as measured by the number of employees. The initial distribution of s_t is calibrated so that the size of the entrant from the model matches the corresponding number in the data. The distribution of c_f is calibrated so that the average exit rate in the model matches the data.

With these parameters in hand, we perform our experiments. Given the additional computational burden introduced by having capital in the model, we group countries together and perform the numerical exercise on these groups.

First we perform the same experiment in an environment in which capital is freely mobile. That is, we set $\lambda = 0$ and $\gamma = 1$ while keeping the other parameters constant. Then we calculate the benchmark case with an adjustment cost. The comparison across these two cases provides us with a measure of the total effects of the "capital mobility friction" in economies with different κ and τ.

Tables 13 and 14 report the results of both experiments.[30] In both experiments, TFP falls monotonically with larger κ and τ. The magnitude of decline is larger with capital adjustment costs, highlighting the importance of capital adjustment across establishments. With capital adjustment costs, TFP falls substantially (by 34%) when we move from the U.S. level of (κ, τ) to the LIC level of (κ, τ). Without the capital adjustment costs, this number is 29%.[31]

[30]The median values of κ are 1.2 for HIC, 1.7 for UMIC, 5.5 for LMIC, and 8.4 for LIC. For τ, the median values are 0.46 for HIC, 0.67 for UMIC, 0.71 for LMIC, and 0.69 for LIC.

[31]This turns out to be larger than the TFP effect in our benchmark model without capital. If the capital is rented by the establishment rather than owned, a model with capital and no adjustment cost is reduced to the benchmark model with a higher labor share. The current model is not directly comparable to the benchmark model because the exit process is also affected by the frictions (k_t enters into the benefit of exiting). Here, the entry/exit rate is significantly more affected by the entry barriers and firing costs than in the benchmark model.

Income Level	U.S.	HIC	UMIC	LMIC	LIC
	$\kappa = 0.26$ $\tau = 0$	$\kappa = 1.4$ $\tau = 0.7$	$\kappa = 3.4$ $\tau = 0.8$	$\kappa = 6.5$ $\tau = 0.9$	$\kappa = 29.9$ $\tau = 1.2$
Y	1.00	0.27	0.19	0.16	0.10
L	0.60	0.19	0.14	0.13	0.09
K	1.00	0.34	0.25	0.22	0.14
w	1.00	0.66	0.60	0.55	0.43
TFP $(Y/(K^{\alpha}L^{(1-\alpha)}))$	1.00	0.84	0.80	0.77	0.71
Avg size of total establishments	30.60	188.02	326.20	524.90	1165.90
Avg size of opening establishments	5.80	22.10	37.70	56.80	154.30
Avg size of closing establishments	30.60	9.05	15.20	24.60	55.00
Entry/Exit rate (%)	16.97	5.36	4.78	4.60	4.50
Output per effective worker (data)	1	0.93	0.52	0.27	0.12
Capital per effective worker (data)	1	1.04	0.38	0.21	0.06
TFP (data)	1	0.93	0.72	0.47	0.33
Avg size of total establ. (data)	17.6	16	171.1	270	755.6
Entry rate (data)	0.13	0.10	0.08	0.08	0.07

Table 13: Model without capital adjustment frictions (Y, K, TFP (both model and data), and per capita GNI are relative to the U.S. level)

Income Level	U.S.	HIC	UMIC	LMIC	LIC
	$\kappa = 0.26$	$\kappa = 1.4$	$\kappa = 3.4$	$\kappa = 6.5$	$\kappa = 29.9$
	$\tau = 0$	$\tau = 0.7$	$\tau = 0.8$	$\tau = 0.9$	$\tau = 1.2$
Y	1.00	0.95	0.86	0.74	0.57
L	0.60	0.64	0.62	0.58	0.50
K	1.00	1.48	1.34	1.17	0.91
w	1.00	0.61	0.54	0.49	0.39
TFP $(Y/(K^{\alpha}L^{(1-\alpha)}))$	1.00	0.80	0.76	0.72	0.66
Avg size of total establishments	15.60	129.10	262.40	456.10	1214.10
Avg size of opening establishments	8.04	32.70	48.40	72.80	206.60
Avg size of closing establishments	3.04	6.10	12.30	21.40	57.20
Entry/Exit rate (%)	12.30	4.53	4.51	4.51	4.50
Output per effective worker (data)	1	0.93	0.52	0.27	0.12
Capital per effective worker (data)	1	1.04	0.38	0.21	0.06
TFP (data)	1	0.93	0.72	0.47	0.33
Avg size of total establ. (data)	17.6	16	171.1	270	755.6
Entry rate (data)	0.13	0.10	0.08	0.08	0.07

Table 14: Model with capital adjustment frictions (Y, K, TFP (both model and data), and per capita GNI are relative to the U.S. level)

In both cases, the wage falls substantially, lowering L and increasing the average establishment size. The wealth effect counteracts this force, and it is particularly strong in the case with adjustment cost. This can induce a non-monotonic behavior in L (and K), as shown in Table 14. Output and employment fall much more with larger κ and τ when adjustment costs are absent, reflecting a smaller wealth effect in this case. The wage decline is larger than in the case without capital, mainly reflecting that when capital is incorporated into the model, production becomes closer to constant returns to scale. This is also reflected in the dramatic change in average size in reaction to the increase in frictions. In both Tables 13 and 14, the entry/exit rate changes substantially when frictions increase from the U.S. level to the HIC level, but it does not change much with further increases in frictions. This is mainly due to how the fixed operating cost c_f is distributed in the model—the distribution of c_f reflects the pattern of exit rates in the cross section of the U.S. economy. Recall, from Section 3.4, that we set the distribution of c_f to match the pattern of exit rates across different establishment sizes. In order to match the fact that many large establishments exit every year, we assume that with a 4.5% probability each establishment is hit by a shock that requires a very large value of c_f to be paid in order to continue operating. This 4.5% acts as the exogenous component of the exit rate, and the entry/exit rate cannot fall below this rate. Thus, once the entry/exit rate gets close to this level due to larger frictions, a further increase in frictions does not have a large impact on the entry/exit rate. The aggregate capital stock K may or may not increase with frictions when capital adjustment costs exist—with adjustment costs, an "inefficient" establishment tends to hold too much capital and an "efficient" establishment tends to hold too little capital, and an increase in frictions exacerbates this distortion in both categories.

The entry barriers and firing costs have larger impacts on TFP when there are capital adjustment costs. The capital adjustment costs hinder the reallocation of capital to a productive establishment. When capital adjustment costs are absent, the friction to the labor reallocation can be "substituted" by the capital reallocation—more capital can be allocated to the productive establishments. With capital adjustment costs it is also difficult to reallocate capital, and the productivity effects of frictions are strengthened.

6 Comparison to the cross-country micro data

In Section 4, we found that entry barriers affect productivity partially through larger firm size, and firing costs affect productivity through reduced worker turnover. One natural question is: are these predictions consistent with the cross-country firm/establishment level micro data? As Bartelsman, Haltiwanger, and Scarpetta (2007) emphasize, it is extremely difficult to obtain *cross-country comparable* micro-level datasets at the firm/establishment level. Here, we sketch some suggestive evidence.

There are relatively more cross-country comparison studies (including developing countries) of firm size than of turnovers. Tybout (2000), based largely on Liedholm and Mead (1987), argues that firm size tends to be smaller in poorer countries. This seems to be at odds with our mechanism. However, Liedholm and Mead's (1987) study includes the informal sector, while our model describes only the formal sector. Informal firms tend to be small and the informal sector is larger in poor countries, thus the existence of the informal sector biases the size-income relationship in the positive direction.

The recent studies by Bartelsman, Haltiwanger, and Scarpetta (2007) and Alfaro, Charlton, and Kanczuk (2008) look at only the formal sector, and therefore these studies seem to be more comparable to our model. They indeed found that there is a negative relationship between firm size and income across countries. Thus, these studies are *qualitatively* consistent with the results of our model.

To assess whether this prediction is also consistent *quantitatively*, we compare the outcomes of our model (with κ and τ taken from the Doing Business dataset) with the data from two sources.[32] In terms of the average and the variance of establishment size, we compare the model's outcome to the data in Alfaro, Charlton, and Kanczuk (2008). The data on business

[32] Here, because the U.S. value of κ is not exactly zero, we subtract the U.S. value of κ from the original value of κ for each country.

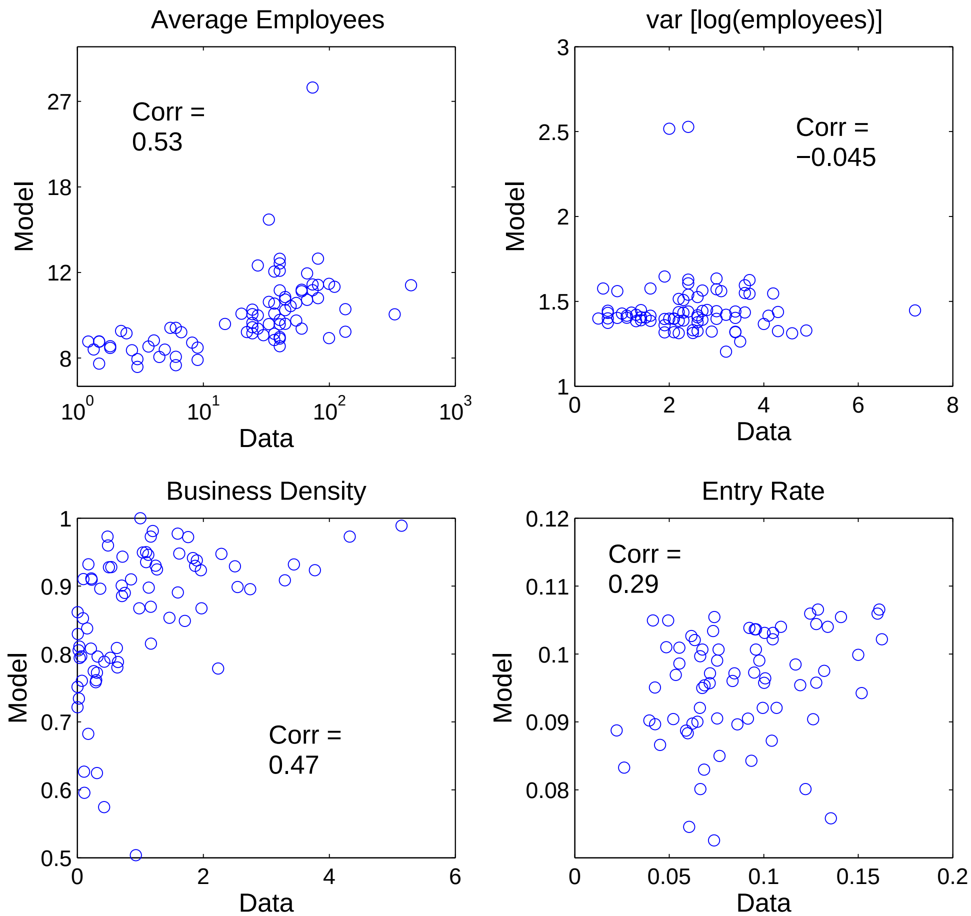

Figure 5: Average establishment size, variance of establishment size, business density, and entry rate in the model and the data. Data Source: Alfaro, Charlton, and Kanczuk (2008).

density and entry rate are those reported by the 2008 World Bank Group Entrepreneurship Survey and Database, where the business density is defined as "the number of total registered corporations divided by total working age population."[33]

The model is consistent with the data in terms of the variation in the average establishment size, business density, and entry rates (with correlations of 0.53, 0.47, and 0.29, respectively). The model misses the variation in the *variance* of establishment size across countries. The fact that the model cannot reproduce the variance of size across countries is a direct consequence of the timing assumption of entry. Because there is no selection of establishments at the point of entry (the entrants observe productivity *after* paying the entry cost), different entry costs do not generate a large difference in productivity distribution. D'Erasmo and Moscoso Boedo (2011) assume that an establishment observes productivity *before* the entry into the formal sector, there is a selection upon entry, and the outcome regarding the variance of the size is closer to that seen in the data.

7 Conclusion

In this paper, we evaluated the effects of entry costs and firing costs on income and productivity. We used the World Bank's "Doing Business" dataset and quantitatively analyzed a general equilibrium industry-dynamics model based on Hopenhayn and Rogerson (1993).

A high entry cost reduces productivity through the wage—the wage is lower in an economy with a higher entry cost, and it keeps a low productivity plant in operation and also makes the average establishment size too large. A high firing cost reduces reallocation of labor from low-productivity establishments to high-productivity establishments.

We found that the quantitative effects of entry costs and firing costs are modest for most of the countries. The linear regression of the data on the model's prediction accounts for 27% of the cross-sectional variation in total factor productivity. Moving the level of entry costs and firing costs from the U.S. level to that of the average of low income countries (the

[33]For the model, we use the number of establishments divided by the number of workers.

countries with Gross National Income below 2% of the U.S. level) reduces TFP by 27% in the model without capital and by 34% in the model with capital and capital adjustment costs.

We focused on the costs that affect the mobility of labor. Although the main part of our model uses labor as the only input, we also extended the model to incorporate the capital stock. We found that when capital adjustment costs exist, the effect of entry costs and firing costs can be substantial.

We made an attempt to compare these predictions directly to the micro-level data. Most of the results are qualitatively consistent with the data, but the model only captures a part of the quantitative variations that are observed in the data. Further quantitative evaluations of richer models are left for future research.

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