Doing Business in Developing Economies: The Effect of Regulation and Institutional Quality on the Productivity Distribution

Job Market Paper

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Abstract

This paper investigates the effects of regulation uncertainty on the innovative behavior of firms, and on the efficiency of the Schumpeterian "creative destruction" process. It argues that regulation uncertainty, caused by a poor institutional environment, distorts the selection process of firms and leads to high observed reallocation, but low productivity. I modify the Hopenhayn (1992) industry equilibrium model by allowing firms to engage in innovative investment, and by introducing an uncertain innovation cost. Then, I study the entry and exit decision of firms, their innovative behavior, and the subsequent industry evolution. In equilibrium, I find that a more uncertain cost creates distortions in the reallocation process that lead to lower average productivity, size, and innovative investments, having similar effects as an increase in the magnitude of the cost. This indicates that, in addition to the level of regulation, *unpredictability* of regulation is an important source of inefficiency in the reallocation process.

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1 Introduction

How efficient is the reallocation process across countries?[1] According to Schumpeterian creative destruction theory, reallocation, either coming from firm entry and exit, or from the shift of resources from contracting to expanding businesses, should increase aggregate productivity.

While empirical evidence shows that reallocation contributes positively to aggregate productivity growth across countries, it also suggests that the contribution is smaller in countries with an "excessive" regulatory burden (Loayza *et al.*, 2005b).[2] Moreover, many countries with seemingly high regulation exhibit large amounts of reallocation, which raises the question of the extent to which reallocation in these countries is efficient.

In this paper I study the effect of institutions on the innovative behavior of firms, and on the efficiency of the reallocation process. Several aspects of the institutional environment affect the cost of innovating, for instance, regulatory constraints, corruption, and political instability. I focus on two dimensions of regulation: its magnitude, and more importantly, the arbitrary enforcement of regulation across businesses, which I refer to as "regulation uncertainty." While the effect of higher regulation on innovative activity and reallocation has been explored in the literature, there have been few attempts at understanding the effects of regulation uncertainty.[3] The centerpiece of this paper is the idea that higher or more uncertain innovation costs distort firms' innovative behavior, and hence introduce inefficiencies in the reallocation process that lead to lower aggregate productivity.

There is growing evidence that policy- and in particular regulation- uncertainty is a major problem for entrepreneurs. To cite a few examples, the World Bank's *World Development Report* (2005) finds that in developing countries policy uncertainty is the most frequently cited "major or severe" constraint to business activities. Hallward-Driemeier and Stewart (2004) find that in Peru, 79% of firms surveyed by the World Bank's *Investment Climate Assessment* report that the interpretation of existing regulations is highly unpredictable. More generally, factual evidence suggests that firms often perceive regula-

[1]The term "reallocation" refers to labor and capital reallocation across establishments or firms. In this paper I focus on two measures of reallocation: firm turnover (the sum of entry and exit), and productivity dispersion.

[2]The contribution of firm entry and exit is typically measured at a 5-year or longer horizon. See Bartelsman and Doms (2000), Haltiwanger (2000), Foster, Haltiwanger and Syverson (2005), and Bartlesman *et al.* (2005).

[3]For instance, Lambson (1991) studies innovative behavior under uncertain demand conditions, which could be applied to the present context also.

tion itself as a source of uncertainty. According to the Economist Intelligence Unit (2005), regulation "has become a major source of risk" for businesses, and "regulatory risk is seen by executives as the most significant threat to business, ahead of country risk, market and credit risk, IT and people risks, or terrorism and natural disasters." Stringent regulation is also likely to be unevenly enforced in countries with poor institutional quality, as regulation stringency is positively correlated with widespread corruption, lack of an independent and transparent judiciary system, and political instability across countries (Loayza *et al.*, 2004).

A comparison of the privatization process that took place in Argentina and Chile illustrates how regulation tends to be more unstable when it is implemented in a poor institutional context.[4] At the beginning of the 1990s, Argentina began the privatization of telecommunications and utility companies (electricity, gas, water, and others), and regulatory agencies were created to design and enforce the regulation of the newly privatized industries. However, regulatory agencies were partly or entirely run by government bodies, and became hostages of political interests. Consequently, regulatory policy was highly volatile. Agencies often introduced arbitrary changes in the rules and violated established agreements, which resulted in endless legal disputes between the companies and the government. Moreover, the judiciary had little independence from the executive, impairing companies' recourse to the courts.

In contrast, the Chilean privatization process was marked by the desire of the government to develop a competitive market economy, with, for instance, the creation in 1973 of the Antitrust Commission to ensure competitive behavior by private firms in all industries. Regulatory policy -designed to increase competition rather than protect incumbents' interests- has been highly stable with respect to political fluctuations, and whenever deviations from established rules have occurred, these have in general been predictable. The stability of the policy in Chile is attributed to its high institutional quality, with a competent bureaucracy setting long-term goals and promoting transparency, an independent judiciary system, and overall political stability.

These two contrasting examples suggest that the institutional environment in which regulation is implemented affects the ultimate outcome, that is, firms' actions in the market. An increasingly unstable environment will likely make firms more sensitive to even small changes in regulation.

[4] A detailed comparative analysis of the two processes is provided by Bergara and Pereyra (2005).

This paper takes a Schumpeterian approach to study the effects of regulation uncertainty on productivity dynamics, by focusing on how uncertain innovation costs affect innovation decisions, and the subsequent entry and exit of firms in the industry. While the ultimate interest of the paper is looking at average productivity effects, I also look at *productivity dispersion*, as the latter captures important characteristics of the reallocation process: that is, an efficient selection of firms should cause dispersion to contract as cohorts grow older. Moreover, productivity dispersion also provides information about the intensity of the "market experimentation" process: that is, a higher productivity dispersion should indicate that firms engage more in innovative investment, which has random returns in terms of productivity gains. Recent studies, for instance, have documented that young firms in the U.S. display greater dispersion of productivity relative to Europe, which arguably points to a more intense market experimentation taking place in the U.S., especially among young businesses.[5] However, especially in developing countries, the empirical relationship between regulation, market experimentation, and reallocation measures remains unclear, because of measurement difficulties and endogeneity problems. I propose therefore to analyze the relationship between regulation and reallocation in a theoretical framework that allows for firm heterogeneity, and where the the industry is continuously renewed by the entry and exit of firms.

The model I use to explore the effects of regulation and institutional quality on reallocation is based on Hopenhayn (1992) and Hopenhayn and Rogerson (1993). This class of models has several advantages: first, firms are heterogeneous, which makes it possible to analyze the equilibrium effects of frictions on the behavior of firms across different levels of productivity. Second, in equilibrium the industry displays entry and exit, so that one can look at firm turnover and cohort effects. Finally, although there is intense activity at the micro level as firms enter, exit, and explore productive opportunities, the model produces a stationary equilibrium in which the characteristics of the industry as an aggregate are constant.

My model departs from Hopenhayn (1992) in two respects: first, following Ericson and Pakes (1995), I allow firms to engage in costly innovation to increase their future productivity, thus capturing market experimentation effects.[6] Second, I allow for uncertainty in

[5] They also find that post-entry growth is higher in the U.S., firms are more heterogenous, and differences in dispersion are more apparent in IT-intensive industries. See Haltiwanger *et al.* (2003), and Bartelsman *et al.* (2004)

[6] In contrast to other models of innovation, in this model there are no externalities or spillovers from innovation.

the cost of innovation (which captures regulation uncertainty). Specifically, in each period each firm receives a random realization of the investment cost, so that firms with similar characteristics end up facing different costs.

I begin by calibrating a version of the model without regulation uncertainty to match key moments of firm dynamics and the productivity distribution in the U.S., my benchmark economy.[7] Next, I analyze the effect of changes in the *magnitude* and *uncertainty* of the innovation cost on firm turnover, productivity, size, and investment, for different cohorts of firms. Namely, I compare the effects of a change in the magnitude of the cost (which corresponds to the "traditional" effect of stringent regulation), versus introducing uncertainty in the cost in the form of a mean-preserving spread.

I find that more uncertain innovation costs have similar, (negative) effects on average productivity, size, and investment, than when the innovation cost increases because of more stringent regulation. In equilibrium, uncertainty distorts the selection process by allowing some inefficient firms to delay their exit, while some potentially good firms are eliminated from the industry. This ultimately leads to lower aggregate productivity and innovative investment. Similarly, a higher (deterministic) innovation cost reduces innovative investment at all productivity levels, causing incumbent firms to receive lower future productivity shocks, and low-productivity firms to stop investing altogether, leading to a drop in aggregate productivity.

Interestingly, I find that neither a higher nor a more uncertain innovative cost reduce measures of reallocation such as firm turnover and the dispersion of the productivity distribution. In fact, both of them change the nature of the reallocation process, giving rise to strong inefficiencies: uncertainty, by delaying exit of inefficient firms, and higher innovation costs, by selecting entering firms (which tend to be less productive than incumbents) out of the market. Taken together these results suggest that, in addition to the magnitude, regulation uncertainty is an important channel through which institutions affect firm behavior. This paper offers therefore a possible explanation for the limited success of regulatory reforms in developing countries, and suggests that countries could achieve larger productivity gains if regulation uncertainty was reduced.

The paper is organized as follows. Section 2 offers an overview of firm and productivity dynamics across countries, as well as a comparison of institutional quality indicators, and

[7]Several recent empirical studies, such as Rajan and Zingales (1998), Klapper *et al.* (2004), or Micco and Pagés (2004) have taken the U.S. as a benchmark economy when addressing frictions in developing economies.

discusses the related literature. Section 3 describes a model of industry evolution, the calibration procedure, and the numerical solution for the benchmark model. Section 4 provides results of the simulation exercise when regulation is combined with uncertainty, and Section 5 concludes.

2 Reallocation Facts and Literature Review

There is little question that the reallocation of resources across firms accounts for a significant share of aggregate productivity growth.[8] From a Schumpeterian perspective this is hardly surprising, since it is precisely the reassignment of resources from less towards more productive units that is at the heart of the "creative destruction" process.

Yet, it would be incorrect to conclude that increased reallocation automatically translates into higher productivity growth. Consider, for instance, firm entry and exit. Figures 2-4 depict turnover rates (i.e., the sum of entry and exit) in manufacturing for three groups of countries: Eastern Europe, Latin America, and the E.U. and U.S. They show that firm turnover is equally high among developed and developing countries, and sometimes higher in the latter. (Even abstracting from the unusually high turnover taking place in Eastern Europe in the early transition years, levels remain comparable to industrial countries toward the end of the 1990s.) This stylized fact has been noted before in firm-level empirical studies: for instance, Roberts and Tybout (1996) note that "the degree of flux in the manufacturing sectors of semi-industrialized countries is on average *greater* than that found in the North." More recently, Bartelsman *et al.* (2004, 2005) provide detailed documentation on firm dynamics and productivity for a group of OECD and developing countries, finding similar patterns. They observe that "[r]elatively high firm turnover rates are observed both in countries with high income levels and/or high growth rates as well as in poorer and/or slow-growth countries (and vice-versa)." This evidence compels us to examine whether the observed measures truly reflect high competition and efficient creative destruction, or rather wasteful reallocation.

Another important dimension of the creative destruction process is productivity dispersion. For instance, if selection effects are solely determined by market forces, the initial productivity dispersion across entering firms should progressively contract as firms become

[8] For the U.S., see for instance Davis and Haltiwanger (1999), Haltiwanger (2000), and Foster *et al.* (2001); for other countries, Aw, Chen and Roberts (1997), Roberts and Tybout (1996), Tybout (1999), and more recently, Bartelsman *et al.* (2004, 2005)

more efficient, and less productive firms are forced out of the market.[9] Hence, the pace and the magnitude of changes in the productivity dispersion can provide substantial information about the selection process. So far, only a handful of empirical studies have attempted to find patterns in the productivity dynamics of young firms across countries. Among them, Bartelsman *et al.* (2003) find that employment in young American firms increases faster than in young European firms, and Haltiwanger *et al.* (2003) find that the dispersion of technology investment per worker decreases with age faster in the U.S. than in Europe, which is consistent with the fact that in the U.S. young firms display greater productivity dispersion relative to Europe.[10]

These facts suggest that young firms in the U.S. should have a larger scope for "market experimentation", that is, they should be better able to allocate resources to the search for the best combination of factor inputs and technology. By the same token, in countries where barriers to experimentation are large, one should observe (other things equal) a less disperse productivity distribution among young firms, and a slower fall in productivity dispersion with age. Table 2 shows the mean and dispersion of TFP for a sample of industrial and emerging countries relative to the U.S. While the argument appears to hold for most European countries, where regulation is higher and dispersion is lower than in the U.S., it is less clear when emerging countries are included in the picture, since they display higher regulation, poorer institutional quality, but much larger dispersion than the U.S. Differences in regulation and institutional quality are visible in Figure 1, which presents a comparison of governance and regulation indices collected by Loayza *et al.* (2004). The dark bars represent a governance index that combines measures of corruption, rule of law, and government accountability. The light bars represent an index of regulation that affects the innovation process of firms (namely labor regulation, financial regulation, trade restrictions, fiscal regulation, and the effectiveness of contract enforcement regulation). All values are between 0 and 1, where 1 is the worst measure in the case of regulation, and the best in the case of governance. Clearly, a visual comparison of Table 2 and Figure 1 seems to contradict the claim that in countries with more business friendly environments firms have more "market experimentation" opportunities, and hence display a more disperse productivity distribution.

[9] This is the case, for instance, in the theoretical model of Jovanovic (1982).

[10] They also find that there is greater dispersion in productivity, payroll per worker, skill mix of workers, and technology investment per worker among U.S. businesses that invest in technology most actively, than among less active businesses, whereas there seems to be little systematic difference in dispersion between active and inactive businesses in Germany.

This is not to say that econometrically such a relationship is inexistent. For instance, Micco and Pagés (2004) look at the effect of labor regulation on job reallocation, Klapper *et al.* (2004) study the effect of entry regulation on firm entry, while Loayza *et al.* (2005) look at the effects of various regulations on firm turnover and on the contribution of net entry to aggregate productivity growth. All conclude that, to some degree, regulation affects reallocation negatively. However, results from cross-country studies that use industry-level data are subject to major caveats: first, comparability across countries is often problematic, as data are collected separately in each country, sometimes using different protocols.[11] Second, the presence of measurement error in dependent and explanatory variables (particularly in institutional variables) is likely to cause biases in the estimated coefficients. It is therefore important to develop theoretical frameworks that allow us to understand better the mechanisms underlying the observed relationships.[12]

Likewise, few empirical studies have looked at the influence of institutional quality on the way that regulation is enforced. For instance, Loayza *et al.* (2004, 2005a) find that labor market, product market, and fiscal regulation hamper GDP growth, exacerbate volatility, and increase the size of the informal sector. Furthermore, the negative effects of excessive regulation are aggravated in countries with poor governance. In looking at firm dynamics, Oviedo (2004) finds that relaxing entry regulation together with improving institutional quality benefits the entry of small firms relatively more, and this result is most significant in transition economies.

On the theoretical side, a number of studies have highlighted the role of institutions in explaining inefficiencies in the reallocation of jobs. Bertola and Rogerson (1997) focus attention on the surprisingly similar job flows, yet large differences in labor market legislation between Europe and the U.S. They show that wage compression in the E.U., in combination with labor market rigidities, leads to rates of job turnover comparable to those observed in the U.S., although workers in the more rigid economy experience longer unemployment spells. Caballero and Hammour (1996, 1998) explore reallocation inefficiencies that arise because workers and firms engage in relations that entail a certain degree of specificity; as a result, when the relation dissolves some of its value is lost, which causes an ex-post holdup problem. They argue that synchronized job creation and destruction indicate an efficient reallocation process, and they find evidence of inefficiencies in the U.S.

[11] One exception is Bartelsman *et al.* (2005).

[12] Schiantarelli (2005) offers a complete review of the literature on product market regulation and economic outcomes.

over the course of the business cycle, as job destruction outpaces job creation during downturns, and depressed job creation lingers even as the economy recovers. The presence of inefficiencies in economies like the U.S., with relatively few institutional failures, suggest that in developing economies, which typically suffer from deep institutional deficiencies, reallocation inefficiency may be quite large.

This paper also relates to two strands of the literature on "creative destruction." The first one evaluates the productivity gains from the wave of market-oriented reforms that began in the 1980s across many parts of the world. Following the seminal paper by Olley and Pakes (1996), who find that deregulation in telecommunications in the U.S. led to significant productivity gains, Pavcnik (2000) and Bergoeing *et al.* (2005) find that trade liberalization (and other market-oriented reforms) in Chile led to steady increases in productivity, coming both from within firms and from the entry of new, more efficient ones.[13] Likewise, Eslava *et al.* (2004, 2005a, and 2005b) find that reforms in Colombia are associated with a more efficient selection process (especially on the exit margin), although productivity gains have been modest.[14] Kugler (2000) studies the effect of the Colombian labor reform of 1990 on worker flows, and finds that hazard rates into- and out of unemployment increased after the reform. Alonso *et al.* (2005) use a general equilibrium approach to evaluate the impact of the liberalization of fixed-term contracts in Spain. They find that the use of fixed-term contracts increases equilibrium unemployment, but also increases productivity.

The second, led by Aghion et al (1992, 2001), focuses on the innovation process itself. In contrast to these models, however, in my model firms do not innovate in order to capture rents, but rather to survive the competitive pressure of outside, more efficient firms. To a lesser extent, my model also relates to Parente and Prescott (1994), who study the effects on productivity of barriers to technology adoption in a model with firm heterogeneity. Although their predictions are similar in terms of average productivity effects, their model ignores the effects on reallocation, since it displays no entry or exit, and they do not address the effects on dispersion.

Finally, this paper relates closely to Aghion *et al.* (2005), who study the effects of entry

[13]Recent theoretical work (for instance, Bernard *et al.*, 2003, and Melitz, 2003) has supported these findings by showing how, in a market with heterogeneous producers, lowering external barriers encourages the reallocation of resources in favor of more productive firms.

[14]A possible explanation for this, as Bond *et al.* (2005) argue, is that in "crisis-prone" countries, like Colombia, trade liberalization is often accompanied by surges in volatility, which distort the selection process and lead to lower aggregate productivity.

liberalization in India on the productivity distribution. They build a Schumpeterian model to study heterogeneous firms' innovative response to external competitive pressures. In the model, external pressure causes productive firms to innovate more, while less productive firms innovate less; as a result, increased entry leads to larger within-industry productivity dispersion, which is corroborated by the data. However, my paper differs in an important aspect, namely the presence of uncertainty as a second channel by which regulation affects reallocation and productivity. As I discuss later on, this second channel opens the possibility for inefficiencies in the reallocation process, and shows that lowering barriers to reallocation may have smaller effects in a poor institutional environment.

3 An Industry Evolution Model

In this section I explain the industry evolution model I develop to analyze the effects of poor institutional quality on productivity dynamics. The basic structure of the model follows Hopenhayn (1992) and Hopenhayn and Rogerson (1993). The industry is characterized by a continuum of heterogeneous firms producing a homogeneous good in a perfectly competitive market. There is only one input - i.e. labor - denoted by z, and each firm produces according to a stochastic production function $f(s, z)$, where s is an idiosyncratic productivity shock. The production function is strictly increasing in s and strictly concave in z, and satisfies $f_s > 0$, $f_z > 0$, and $f_{zz} < 0$.

In the model, the optimal choice of the input z depends on current productivity s, and output and input prices, p and w. We assume that w is exogenously determined, and, being in a competitive industry, that firms take p as given (in equilibrium p is determined by the market clearing condition; for now let us just assume it is given). Thus, in each period firms solve the following static problem:

$$\max_z pf(s, z) - wz - pc_f \tag{1}$$

where c_f denotes a fixed cost incurred in each period by each incumbent firm, measured in units of output. The term pc_f implies that firms with low current productivity will find it too costly to stay in the market. In fact, the presence of a fixed operating cost is necessary to ensure a positive amount of exit in equilibrium; otherwise, firms with low productivity will choose to produce no output and wait indefinitely until they get a favorable shock. In what follows, I choose wage to be the numéraire and set $w = 1$. Thus, given s and p, rewrite the per-period profit as follows:

$$\pi(s,p) = pq(s,p) - z(s,p) - pc_f \tag{2}$$

where $q(s,p)$ represents optimal production.

Next, I turn to productivity shocks and the process of "market experimentation." Productivity shocks are independently distributed across firms with conditional cumulative distribution $F(s'|s,x)$, where s' is next period's productivity shock, x represents innovative investment, and F is assumed to be continuous and strictly decreasing in s and x ($F_s < 0$ and $F_x < 0$). Innovative investment can be interpreted as "active learning," as firms invest to explore profit opportunities. Namely, in every period firms may improve their productive prospects by investing a variable amount x in innovation. Moreover, because innovative investment is an inherently risky activity, it is assumed that a higher investment x increases the conditional mean but also the *variance* of s'. The cost of innovating is quadratic and given by $c_x x^2$, where c_x represents barriers to investment due to the regulatory environment.

A poor institutional environment typically affects not only the mean (regulation related) investment cost, but it also generates uncertainty about how the cost is enforced. As discussed earlier, the uneven enforcement of regulation has many possible origins, such as corruption or political instability. I assume therefore that, before choosing the amount to invest in innovation, firms receive a draw from a random cost variable, so that c_x can take two values, $c_x = c_x^h$ ("high") with probability p_x, and $c_x = c_x^l$ ("low") with probability $1 - p_x$, and c_x is *i.i.d.*. The distance between c_x^h and c_x^l reflects therefore the amount of uncertainty faced by firms when investing in a poor institutional environment.

Decisions are made according to the following timing: at the beginning of each period, before receiving any information, an incumbent firm decides whether to stay or exit the industry. If the firm decides to exit, it incurs the corresponding (constant) bankruptcy fee, denoted by ϕ. If the firm decides to stay, it incurs the fixed cost pc_f, observes its current productivity shock s and innovation cost c_x, and makes production and investment decisions. The incumbent firm's value function can be therefore written as follows:

$$V(s, c_x, p) = \max_{x \geq 0} \left\{ \pi(s,p) - c_x x^2 + \beta \left[\max\{-\phi, E[V(s', c_x', p)|s, x]\} \right] \right\} \tag{3}$$

where $E_{s'}[V(s', c_x', p)|s, x]$ is the firm's expected future value over productivities, given the output price and future investment cost, and conditional on the current productivity s

and investment x. The first order condition of the value function implies that the optimal choice of x depends on the current innovation cost c_x and on the marginal expected value of investing, given by the (expected) marginal gain in productivity. In what follows, I denote the decision rules generated by the maximization problem (3) as $I(s, c_x, p)$ and $\chi(s, c_x, p)$, where $I(s, c_x, p)$ represents investment in innovation, and $\chi(s, c_x, p)$ the exit rule (so that $\chi = 1$ if the firm exits, and $\chi = 0$ if it stays).

Notice that, as $\pi'(s) > 0$, $F_s < 0$, and $F_x < 0$, future expected profits $E[V(s'c'_x, p)|s, x]$ are strictly increasing in s and x. In addition, given the productivity shock structure chosen in section 3.2, a higher persistence of the productivity shock will, *ceteris paribus*, increase optimal investment x, as the gains from investment are likely to last longer. Likewise, for a given persistence, higher current productivity increases the optimal choice of investment, as higher current productivity implies both larger current revenue and better future survival prospects. Finally, a higher output price increases current and future revenue at all levels of output, thus increasing the optimal amount of innovative investment x.

Let us now turn attention to entry decisions. There is a continuum of identical potential entrants that decide whether to enter by comparing the one-time entry cost pc_e to the value of entering the industry. Once they enter, they receive an initial productivity shock s_e, drawn from an initial productivity distribution $v(\cdot)$, and then evolve as any other incumbent with $x_{t-1} = 0$. Initial productivities are identically and independently distributed across entering firms, so that the expected value of the potential entrant is equal to:

$$V_e(p, c_x) = \int V(s_e, c_x, p) v(s_e) ds_e \tag{4}$$

Hence, firms will enter each period if their expected value is larger than the entry cost. Denote M the mass of entering firms in equilibrium, where $V_e = pc_e$. In this model, the previous level of investment x is not a state variable in the incumbent's maximization problem, although it *does* determine the conditional distribution of the current shock s. Hence, the state of the industry can be fully summarized by the distribution of firms along s and c_x at time t, which I denote by $\mu_t(s, c_x)$. In the numerical solution, s is discretized, so that $\mu_t(s, c_x)$ gives the the mass of firms at each productivity level and cost. Moreover, given (s, c_x, p), the decision rules $I(s, c_x, p)$ and $\chi(s, c_x, p)$ will bring the industry from state μ_t to a new state μ_{t+1}. The dynamics of the whole economy can be therefore summarized by an operator $T(\mu, M, p)$, with $\mu_{t+1} = T(\mu_t, M, p)$, so that one can define a *stationary equilibrium* by the values $p^* \geq 0$, $M^* \geq 0$, and μ^* satisfying the following conditions:

(i) entry satisfies $V_e(p^*) \leq p^* c_e$, with equality if $M^* > 0$

(ii) the distribution over states is stationary, that is, $\mu^* = T(\mu^*, M^*, p^*)$

(iii) the equilibrium price p^* is determined by aggregate supply and demand, that is, $Q^s(\mu^*, M, p^*) = \int q(s, p^*)\mu^*(s, c_x)ds + M \int q(s_e, p^*)v(s_e)ds_e = Q^d(p^*)$

where the demand function $Q^d(p^*)$ is exogenously given, with $Q^d_p(p^*) < 0$. The stochastic structure of the shocks in this model guarantees that, in the stationary equilibrium, the productivity distribution and aggregate supply are constant. Thus, the equilibrium output price will also be constant, and it will satisfy condition (i). Note that, by condition (ii), the number of firms in the industry is constant. This implies that if a number M of firms enter each period, an equal number M must exit, so that net entry is equal to zero. Finally, Hopenhayn (1992) shows that the operator T is homogeneous of degree one in M and μ. Homogeneity implies that the equilibrium rate of entry –the ratio of M to μ- is independent of the actual number of firms, since, to keep the distribution constant, doubling the number of total firms requires doubling the number of entrants.

To conclude, note that regulation in this model is captured by three parameters: the entry cost, the bankruptcy cost, and the innovation cost. Arguably, the choice of innovation cost to be the only regulation parameter that creates uncertainty is arbitrary. However, introducing similar randomness in entry or exit costs would cause the equilibrium distribution to change over time. Under this scenario, firms would have to take into account the entire productivity distribution in their optimization problem, and the productivity distribution itself would become an additional state variable, which complicates the numerical solution considerably.[15] Moreover, introducing uncertainty in either entry or exit costs should not fundamentally change my results, as additional uncertainty is likely to make the selection process even more "noisy," increasing the resulting productivity dispersion. Next, I describe the algorithm for finding the equilibrium with entry and exit, and the calibration procedure to generate the numerical solution.

3.1 Algorithm

To find the equilibrium values p^*, M^*, and μ^*, I follow the algorithm described in Hopenhayn and Rogerson (1993), which consists of three steps. First, for an initial p and a given

[15] Ways to simplify the problem have been put forth, for instance, by Krusell and Smith (1998).

set of parameters, I solve (3) via value function iteration. I integrate then the value function over the productivity distribution of entrants to obtain V_e, and compare it to the cost of entering, pc_e. If $V_e > pc_e$, I reduce p and solve (3) again, repeating the procedure until condition (i) of the equilibrium is satisfied.

Second, following condition (ii), I find μ^* up to a scale factor.[16] That is, given p^* and an arbitrary number of entrants $\widetilde{M}$, I use the decision rules $\chi(s, c_x, p^*)$ and $I(s, c_x, p^*)$ to compute the transition function $T(\mu, \widetilde{M}, p^*)$ that reassigns firms in μ_t to μ_{t+1}. Starting from an arbitrary distribution μ^0, I reassign firms using T until a fixed point is reached. I call this invariant distribution $\tilde{\mu}$.

Finally, I compute aggregate supply using the invariant distribution $\tilde{\mu}$, and I compare it to the industry demand corresponding to p^* (condition (iii)). If $Q^s(\tilde{\mu}, M, p^*) > Q^d(p^*)$, I reduce the number of entrants to reduce aggregate supply, and compute the invariant distribution for the new M. I repeat the procedure until the market clears. The resulting M^* and μ^* complete the stationary industry equilibrium.

The definition of the equilibrium in the previous section states that the industry could display an equilibrium with or without entry and exit. Since the economies under study display large amounts of entry and exit each year, it is natural to focus on the case generating entry and exit in equilibrium.[17] Hence, the choice of parameters for the numerical solution are such that in equilibrium the industry displays positive entry and exit.

3.2 Benchmark model and calibration

I begin the analysis by calibrating a version of the model with constant innovation costs c_x to match a set of statistics for the U.S. There are two reasons for doing so. First, the goal is to study the effect of distortions caused by poor institutional quality, therefore, it seems natural to begin by studying a benchmark economy with relatively few distortions and good institutions. Second, a multitude of studies have used similar models to reproduce patterns observed in the U.S., and being able to compare their results to mine is of interest. I then vary innovation costs in the calibrated model: I first increase them, and then make innovation costs random, and for each case I solve the model and compute the resulting invariant productivity distribution. Finally, I simulate an industry to obtain productivity

[16] The linear homogeneity of T with respect to M and μ implies that, if $\hat{\mu}$ is the fixed point when $M = 1$, then $\widetilde{M}\hat{\mu}$ is the fixed point when $M = \widetilde{M}$.

[17] Hopenhayn (1992) shows that the equilibrium with entry and exit is unique; on the other hand, in the case without entry/exit, there is a continuum of equilibria.

and size statistics for several cohorts of firms. The main parameters of the calibration are summarized in Table 3.

The idiosyncratic productivity s is set to follow a mean-reverting process of the form

$$s_{t+1} = \rho s_t + x_t \epsilon_{t+1} \qquad 0 \leq \rho < 1 \tag{5}$$

where the shock ϵ is an *i.i.d.* log-normal random variable and where $\log(\epsilon)$ has mean μ_ϵ and standard deviation σ_ϵ. Note that the distribution of the productivity shock depends on the amount x invested in innovation last period, and, because investment multiplies the shock, it will affect the mean and the variance of s.[18] Notice also that if a firm does not invest, its future productivity declines by a proportion equal to $1-\rho$: this captures the competitive pressure that outside technological progress exerts on the firm, forcing it to innovate or exit.[19] The pace of "technological change" $1/\rho$ has an ambiguous effect on the firm's incentives to innovate. If ρ is low, the firm can only survive to the extent that it invests to keep its productivity from falling; if ρ is too low, however, the benefits of investing are short-lived, and hence the firm may be better off shutting down.

I make a discrete approximation for the process (5) by constructing a grid of 200 points for s, and 250 points for x, for a given set of parameters ρ, μ_ϵ, and σ_ϵ.[20] Since x is endogenously determined, I choose the grid such that firms' choices are not constrained by the upper bound of x, while the range of s is chosen so that its upper bound stands three standard deviations away from the mean when x is equal to its upper bound. I then construct a matrix of transition probabilities for each value of x, so that a total of 250 matrices of dimension 200-by-200 were constructed.

The parameters ρ, μ_ϵ, and σ_ϵ are chosen to match the estimates of the first and second moments of the profitability shock process estimated by Cooper and Haltiwanger (2000), henceforth CH, using data for approximately 7,000 U.S. large manufacturing plants continually in operation between 1972 and 1988. While the distinction between *productivity* and *profitability* shocks is empirically important, in the model it is not, since p and s multiply

[18] More formally, $E(s|x=x_0) = \frac{x_0 E(\epsilon)}{(1-\rho)}$ and $var(s|x=x_0) = \frac{x_0^2 var(\epsilon)}{(1-\rho^2)}$, where $E(\epsilon) = \mathrm{e}^{\mu_\epsilon + \frac{\sigma_\epsilon^2}{2}}$ and $var(\epsilon) = \mathrm{e}^{2\mu_\epsilon + \sigma_\epsilon^2}(\mathrm{e}^{\sigma_\epsilon^2} - 1)$

[19] While outside competitive pressure has been traditionally modeled also as coming from vintage effects, in this model entering firms are less productive on average than incumbents, which is consistent with the data. Therefore, it is assumed that outside competitive pressure is reflected in the pace at which the technology of incumbent firms becomes obsolete.

[20] The large number of grid points for s allows me to have a wide range for s, yet with small gaps between the grid points. This is necessary since the range of s widens as x increases.

each other (see Foster, Haltiwanger and Syverson, 2005).

CH decompose the stochastic process of productivity into aggregate and idiosyncratic shocks; here, I abstract from aggregate shocks, and only consider the first and second moments of the productivity distribution, together with the persistence parameter ρ. Moreover, in contrast to CH, the process (5) is conditional on investment x. I need therefore to choose a value $\bar{x}$ such that the mean and the variance of s, given $\bar{x}$, match the estimated moments in CH. To do so, I set the persistence parameter equal to that estimated by CH, $\rho = 0.885$. Then, I set $\bar{x}$ to be 75 grid-points below the upper bound of x, and for this value the corresponding remaining parameter values μ_ϵ and σ_ϵ are chosen to generate a standard deviation for s equal to 0.88 and a mean value of 1.23. Admittedly, the choice of $\bar{x}$ is arbitrary. However, the choice of μ_ϵ and σ_ϵ adjust to $\bar{x}$ so that the resulting moments for s match those in CH. Hence, neither s nor the numerical results depend on $\bar{x}$.

In the model it is important to work with short time periods, as much of the effects of regulation happen through selection of young firms, who either grow or exit. I therefore set the time period to be one year, and attempt to match the 1990s. Accordingly, the discount rate β is set to 0.95, which corresponds to an annual interest rate of roughly 5.26 percent. Although the time period matches the measure of turnover rates and size distributions provided by Bartelsman *et al.* (2005), the same authors provide productivity statistics only at five-year spans; to make my model implications comparable, I will also present the productivity statistics over a period of five years. In the model, the production technology is standard:

$$f(s,z) = sz^{\alpha} \qquad \alpha < 1 \tag{6}$$

where α is set to be equal to 0.5. After some algebra, firms' profits can thus be written as follows:

$$\pi(s', p) = (\gamma - 1)\left(\frac{1}{\gamma}p\right)^{\frac{\gamma}{\gamma-1}}\left(\rho s + x\epsilon'\right)^{\frac{\gamma}{\gamma-1}} - pc_f \tag{7}$$

where $\gamma = 1/\alpha$. [21] Finally, in what follows I consider a linear demand function with intercept D, so that $Q^d(p) = D - p$. Recall from the previous section that the operator T is homogeneous of degree one in μ and M. As a result, in equilibrium the entry/exit rate is independent of the actual number of firms. Therefore, the choice of D is irrelevant in

[21] The reason to set the share of labor at 0.5 is that profit should not increase in x faster than the cost of x, which is quadratic. From equation (7), we can see that profit is quadratic in x when α is 0.5

determining the rate of firm turnover, and its value is chosen so that the aggregate quantity produced under the benchmark model is equal to the aggregate quantity in the model with uncertainty.

The remaining parameters, namely the entry cost c_e, the exit cost ϕ, the fixed operating cost c_f, and the initial productivity distribution $v(\cdot)$ are chosen so that the resulting industry equilibrium matches the U.S. annual turnover rate, the size distribution of firms, the employment distribution across sizes, and the coefficient of variation of the productivity of entering and incumbent firms.[22] Following Hopenhayn and Rogerson (1993), the initial productivity distribution is chosen to be uniform over the lower third of the productivity range for incumbents. Having a lower average productivity for entrants guarantees that the size distribution of entrants displays a lower average than for incumbents. In addition, it is reasonable to assume that, on average, entrants start off less productive, and are more likely to exit, than incumbents, as the data show for the U.S. and other countries. The innovation cost c_x (constant in the benchmark case) is set so that the average expenditure on investment relative to sales matches the U.S. R&D expenditure-to-sales ratio for manufacturing firms performing R&D in 2000, reported by the National Science Foundation 's *Research and Development in Industry* (see the Appendix).

With the parameters in hand, I proceed to solve the model numerically as described previously. That is, I solve the firm's problem by value function iteration, obtain the policy functions χ for exit and I for investment, and calculate the invariant productivity distribution and the equilibrium firm entry/exit rate. The policy functions and invariant distribution also allow me to compute the distribution of firms over different size categories, as well as the share of total employment that each size category accounts for.

Next, I simulate a panel of firms and compute statistics for entering, continuing and exiting firms by cohort. The simulated industry consists of 500 firms, and it is simulated for 500 periods, where I discard the first 50 periods to eliminate the influence of the initial distribution. In each period I use the exit rule χ to determine the number of firms that exit, and replace those firms by an equal number of entrants. Using the investment rule I, I calculate investment decisions for each incumbent and entering firm, which in turn determine the conditional probability distribution of shocks for the period after. Then, in each period, each firm receives an idiosyncratic shock, drawn from the probability distribution implied by last period's investment (for entering firms, the shock is a draw from a uni-

[22] "Size" is defined by employment z.

form distribution, with upper bound set at the lower third of the incumbents' productivity range). I then construct productivity statistics (mean and dispersion) in the same manner as Bartelsman *et al.* (2005), by considering as entrants all firms that entered between t and $t-5$, continuers all firms that are observed between $t-5$ and $t+5$, and exiting firms all firms that exit between t and $t+5$ (see the Appendix). I also calculate the average and standard deviation of size, productivity, and investment for different cohorts of continuing firms.

In the next section I introduce institutional quality by, first, allowing the investment cost to increase, and, second, by allowing the investment cost to be a random variable. Using the same set of parameters as in the benchmark model, I then compare the resulting invariant distribution to that of the benchmark model. I also report the results of simulation exercises that provide size, productivity, and investment statistics for several cohorts of firms.

4 Results

Table 4 presents summary statistics in the data and the statistics produced by the calibration. The coefficient of variation for entering, continuing, and exiting businesses reported in Panel A is calculated at 5-year intervals in the data, as well as in the model, using the simulated panel. The share of innovative investment to total sales and the firm turnover rate are also reported in Panel A. Panel B provides the size distribution of firms, as the share of firms in each size category, and the share of total employment in each size categoty. Where comparable, the results produced by the benchmark model are similar to Hopenhayn and Rogerson (1993). Most firms are small (although the share of firms with less than 20 employees is significantly smaller in the model than in the data), but most of the employment is concentrated in large firms. In addition, the productivity distribution of entering firms displays larger dispersion (and lower mean) than that of incumbent firms. To be sure, the parsimonious nature of the model makes it difficult to capture many industry characteristics, however, the calibration fits quite well the main characteristics that I am interested in studying here, namely the innovative behavior, the entry/exit rate, and productivity dispersion.

I study the effects of a deterioration in the investment climate by first conducting a "traditional" exercise, where I keep the innovation cost deterministic but change its magnitude. In the calibration the cost is increased from the benchmark case of $c_x = 0.085$ to

$c_x = 0.09$ (a 5.6% change). Keeping all other parameters unchanged, I solve the model, obtain the invariant distribution, and simulate a new industry. Results are reported in the second column of Table 5, where all results are relative to the benchmark case. Firm turnover increases by 15% with respect to the benchmark setup, while average productivity falls by 6.58%, and dispersion (measured by the coefficient of variation) actually increases by 2%. Intuitively, all firms invest lower amounts in innovation, which has two consequences. First, incumbent firms receive lower future productivity shocks, which reduces aggregate productivity; second, investment of firms that are close to the exit cutoff level (many of them entrants) drops to zero, forcing these firms to exit more rapidly (hence the cutoff productivity level increases). Because in equilibrium the number of firms is constant , this increased exit also causes the composition of the industry to change towards a larger number of young (thus small and less productive) firms. Overall, average investment decreases by 7.4%, and because low-productivity firms are more likely to exit than to invest, the dispersion of investment falls.

Table 6 presents the impact of the higher innovation cost on productivity for entering, continuing, and exiting firms. To be consistent with the data, the calculations are made at a 5-year span: they therefore ignore the selection taking place at high frequencies, giving us medium-term effects of the change in the investment cost. Interestingly, the drop in average productivity is relatively larger for continuing firms, since their average productivity falls by 3.6%, while the average productivity of entering and exiting firms falls by 2.9% and 1.8%, respectively. On the other hand, while the dispersion of productivity for entering and continuing firms remains practically unchanged, it increases slightly for exiting firms. This can be explained by the increase in the cutoff productivity level, which also increases the range of productivity levels for exiting firms. However, because the number of firms at low productivity levels increases, the average productivity of exiting firms falls. The size distribution statistics, presented in Table 7, shows that the share of small ($z < 20$) firms increases, as turnover is higher and most entering/exiting firms are small.

Next, I allow the cost to be random, taking values $c_x^h = 0.095$ and $c_x^l = 0.075$ with equal probability. Note that the *average* cost remains the same as in the benchmark case ($\overline{c_x} = 0.085$), so that the only "additional" effect I consider with respect to the benchmark case is uncertainty. Assuming that half of the firms get a high realization and half get a low realization is an extreme example of the "capriciousness" of regulation; however, I study it as a starting point, and will later provide results for an alternative case in which the probabilities of the high and low cost are asymmetric, offering more realistic representations of the uncertainty caused by poor institutional quality.

The third column of Table 5 reports the results of this calibration exercise. At first sight, results differ only by small amounts with respect to the benchmark case. Firm turnover does not change significantly (it decreases by less than 0.1%), the market-clearing price decreases slightly, average productivity decreases by 1.065%, and the coefficient of variation increases by 0.7%. There are more noticeable effects for average size and investment, which fall by 3.29% and 1.22% respectively, and on investment dispersion, which increases by 2.53%.

In fact, although uncertainty does not affect average churning, it significantly affects the *nature* of churning, and the distribution of firms' characteristics. Table 6 shows the effects of uncertainty in innovation costs on the productivity of entrants, incumbents, and exiters. Unlike the previous case of increased innovation costs, under uncertain costs it is exiters that see the largest change with respect to the benchmark case. Indeed, the average productivity of exiters falls by slightly over 4%, while the average productivity of entrants falls by about 2%, and the average productivity of continuers firms falls by less than 1%. Intuitively, a fraction of low-productivity firms receives a low cost draw, and hence are able to continue investing and delay their exit. Moreover, a fraction of "potentially good" young firms receive a high cost draw, therefore stop investing and exit the industry faster. As a result, average productivity of exiters falls. Investment also falls sharply among exiting firms (16.5%), while it falls modestly for entering and continuing firms (less than 3% for entrants and less than 1% for continuers). Not surprisingly, investment dispersion increases for all firms, as firms face uneven costs in this setup. Table 7 shows that the size distribution shifts slightly towards small firms, although less than in the previous case of a higher cost.

I conclude the analysis by solving a more realistic specification of the model, where the probability of getting a high or low cost is asymmetric. In particular, the cost now takes values $c_x^h = 0.09$ with probability $p_x = 0.8$ and $c_x^l = 0.065$ with probability $1 - p_x$. This specification corresponds to a more realistic case in which the majority of firms face a high cost (relative to the benchmark), and a smaller number of "lucky" firms receive a low draw of the cost. While in this model all firms face the same probability structure, which would not be the case if regulation enforcement were endogenous, the asymmetric probability case can be interpreted as uneven enforcement coming over which the firm has no influence, for instance, due to an ineffective bureaucracy subject to volatile, inconsistent policies.

Figures 8 and 9 show the policy function for investment and the resulting invariant distribution of investment for the benchmark model, the case with higher, deterministic cost, and the random cost with asymmetric probabilities. For the latter case, the average investment is plotted in Figure 8 instead of the policy rules for c_x^l and c_x^h, since it is the average investment that determines the equilibrium productivity distribution. Note that the graphs do not display smooth lines due to the discretization of the state-space. Although the differences appear to be generally small, note that the investment rule in the random case is systematically below the benchmark case (Figure 8), and the distribution of investment in the deterministic and random case show a slight shift to the left (Figure 9). In both graphs, there is a visible mass of investment at zero for low productivity levels, because firms receiving bad productivity shocks will opt to exit the industry and hence invest zero. In contrast to the deterministic case, however, the distribution of investment in the random cost case shows that the gap between zero and positive investment is smaller, since firms with low productivity that receive the low cost draw will invest a positive amount instead of exiting.

The overall effects of this setup are summarized in column 4 of Table 5. The effect of turnover is more marked than in the previous case, although the increase is not significant (0.44%). Average productivity, however, falls by 3.69%, while productivity dispersion increases by 1.8%, and more importantly, average size falls by over 7.84%. Average investment also falls more markedly (4.13%), while the dispersion of investment increases by 3.36%.

The simulation results in Table 6 provide a striking view of of how asymmetric random costs affect different groups of firms. First, average productivity of falls by 2.8% for entrants, 4.5% for continuers, and 7.1% for exiters. These results are similar in nature but more marked with respect to the symmetric random cost, in that exiting firms tend to be less productive because low-productivity firms that are "lucky" enough to receive a low draw of the cost are able to invest and remain above the exit cutoff level for a longer time, while "unlucky" young firms are forced out of the industry too quickly. The resulting size distribution –presented in Table 7- shows that the share of small firms increases, which suggests that the number of low-productivity firms increases as less productive firms tend to be small. It is interesting to compare these results with the case of the deterministic, but higher cost. Note that in the deterministic cost case overall average productivity falls more, because turnover increases and all firms invest less; on the other hand, the average productivity of continuers and exiters falls more in the random cost case, and this effect is especially strong for exiters.

The results in panel B of Table 6 show that on average entrants and continuers invest less than in the benchmark case (3.6% and 4.6% less), and the dispersion of investment increases for all three groups of firms, most notably for exiting firms. Indeed, it is particularly striking that although the average productivity of exiting firms falls, its investment dispersion increases even more than for the other two groups (28.7% for exiters, 9% for continuers, and 7.4% for entrants). The results of this case show that firms that get the lower cost draw invest considerably more than those getting the high cost, which increases the dispersion of investment, although altogether firms invest less than in the benchmark case. For less productive firms the effects are larger since firms that get the high cost draw typically invest zero. Finally, notice that compared to the deterministic, higher cost case, entering firms invest more on average in the random cost case (column 1 vs. column 3 in Table 6), although the resulting average productivity is lower.

To summarize, *on average*, the effects of introducing uncertainty in the innovation cost are smaller than in the case of increased deterministic costs. However, a disaggregated analysis shows that the *nature* of churning changes: exiting firms display a lower average productivity compared to the benchmark model, and the selection process of firms is distorted so that some low-productivity firms delay their exit while others exit prematurely. Hence, in the presence of unpredictable regulation inefficiencies arise in the reallocation process, even if the average level of regulation remains unchanged, which highlights the importance of complementing regulatory reform with improvements in overall institutional quality.

5 Concluding Remarks

Why do we observe high amounts of reallocation (firm turnover, productivity dispersion) in countries with high levels of regulation? And why have reforms in some countries failed to increase the contribution of reallocation to aggregate productivity growth?

To answer those questions I build an industry equilibrium model where firms engage in innovation, but face costly *and* unpredictable barriers to innovation. This added friction is intended to capture poor institutional quality, and I show that it distorts the entry and exit decision of firms, and their innovative behavior, all of which determine the equilibrium productivity distribution.

I find that changes in innovative cost (either in magnitude or in nature) increase firm turnover and productivity dispersion. Thus, interpreting surges in such reallocation measures as improvements in the "creative destruction" process could be misleading, especially in countries where regulation is high and institutional quality poor. More importantly, the fact that *uncertainty alone* can cause inefficiencies in reallocation offers an explanation for the limited success of structural reforms implemented across developing countries in recent years, and highlights the importance of combining regulatory reform with improvements in the overall institutional quality.

Admittedly, the model does not incorporate important aspects of the relationship between regulation and firm dynamics: for instance, regulation enforcement, though uneven, is not purely random in reality, as some firms are able to avoid compliance more often than others. Likewise, this model abstracts from strategic behavior present in models of imperfect competition, such as Ericson and Pakes (1995), which, in combination to institutional frictions, could generate important implications for firm dynamics. Extending the model to allow for multiple effects of regulation and institutional quality opens the possibilities for a more complete understanding of its ultimate effects on productivity. Another avenue for further research is the collection of institutional measures capturing the uncertainty associated to regulation, which could be used to test the predictions of the model by estimating reduced form relationships. The challenge is then obtaining objective and accurate measures of the "capriciousness" of regulation across countries or industries.

6 Appendix: Data

The data used to calculate firm- and productivity dynamics across countries come from Bartelsman, Haltiwanger, and Scarpetta (2005).[23] The data were collected as part of World Bank and OECD projects to obtain harmonized, industry-level indicators of firm dynamics and productivity. The main advantage of harmonized data is that it provides the researcher with comparable measures across countries, and it minimizes (as much as possible) biases due to measurement error. For the calibration of the model and the subsequent comparisons, I use data for the manufacturing sector, for all available years between 1990 and 2001.

Firm demographics
U.S. data come from the Census Business Register, 1990-1996.
Turnover: Firm turnover rates are computed as the sum of entering and exiting firms at time t, divided by the total number of firms at t, where entering firms are defined as firms that were not observed in $t-1$, but are observed in t and $t+1$. Employment-weighted turnover is the sum of employment in entering and exiting firms at time t, divided by total employment at t. I exclude one-year firms, as well as firms with less than 1 employee.

Size distribution: Calculated as the share of firms in each size category ($< 20, 20-49, 50-99, 100-499$, and 500+) with respect to the total number of firms, excluding firms with zero employees. The size-employment distribution, is calculated as the share of employment in each size category.

Productivity
U.S. data come from the Economic Census, 1992 and 1998. TFP is measured as the (log of) deflated output (measured as value added, deflated using 4-digit level price deflators), minus weighted (log of) labor and capital. Weights are industry-specific and common to all countries, and they are calculated as the average expenditure shares of inputs in the OECD STAN database (alternatively, some calculations are based on country-specific weights). To mitigate the problem of having different units of measurement, the units of capital are adjusted with a multiplicative factor, such that value added minus payroll reflects a return to capital of eight percent.

[23] Because their study describes the data in great detail, I only highlight the relevant features of the data for this paper, and refer the interested reader to the original study.

Average and dispersion of TFP: Let A be the universe of firms, N the set of entering firms, defined as the set of firms that are observed in t, but not in $t-5$; C the set of continuing firms, defined as the set of firms that are observed both in t and in $t-5$; and X the set of exiting firms, defined as the set of firms that are observed in t, but not in $t+5$. Define w_i as the share of firm i in the industry (e.g., value added, or output share); and let *input* be the sum of input value at the firm level. Then, the un-weighted mean for entrants (similarly, continuers and exiting firms) is equal to

$$\frac{1}{N}\sum_{e\subset N}\log(TFP)_{e,t}$$

and dispersion is measured as the simple standard deviation of $\log(TFP)_{e,t}$. The weighted mean is equal to

$$\frac{1}{N}\sum_{e\subset N}\left(\frac{w_{e,t}input_{e,t}}{\sum\limits_{i\subset A}w_{i,t}input_{i,t}}\right)\log(TFP)_{e,t}$$

R&D to sales ratio: Data come from the National Science Foundation (2000). It is the ratio of total R&D expenditures to net sales of R&D performing companies in manufacturing, in 2000 (measured in current dollars).

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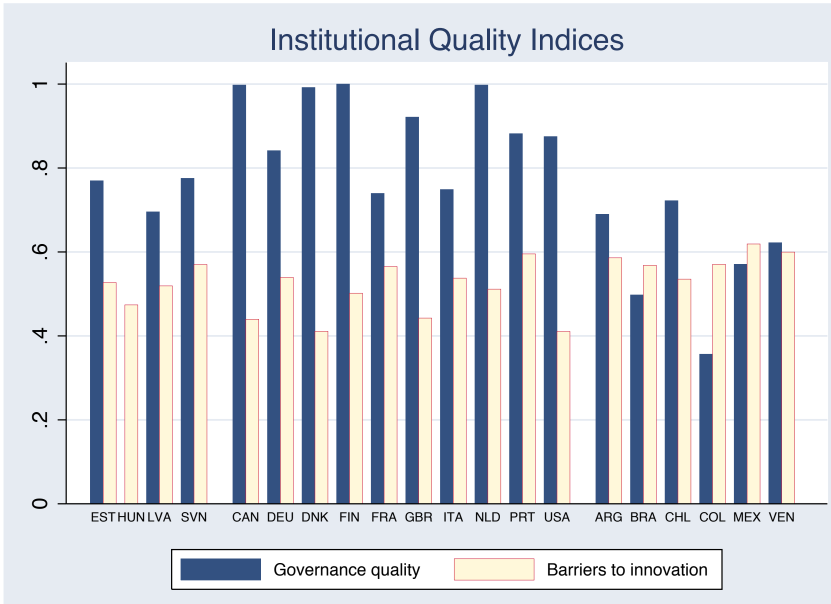
Figure 1: Institutional Quality



Source: Loayza, Oviedo and Servén (2004), and author's calculations.

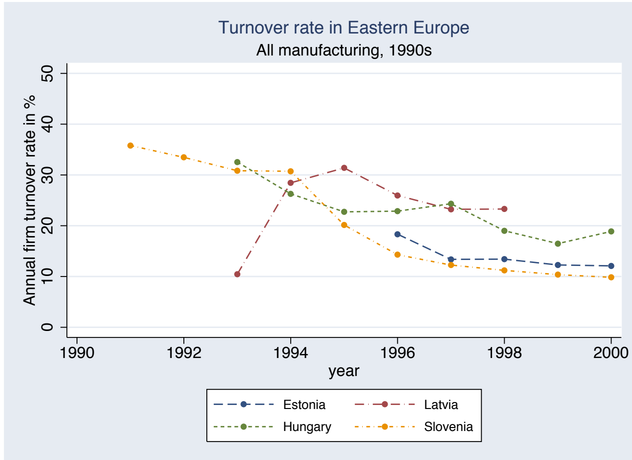


Figure 2: Turnover in Eastern Europe

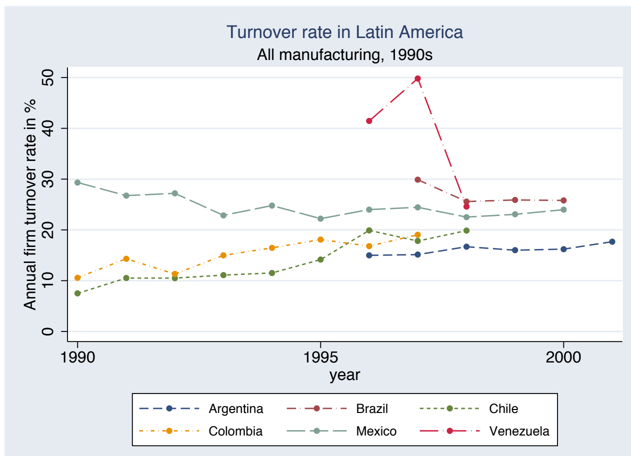


Figure 3: Turnover in Latin America

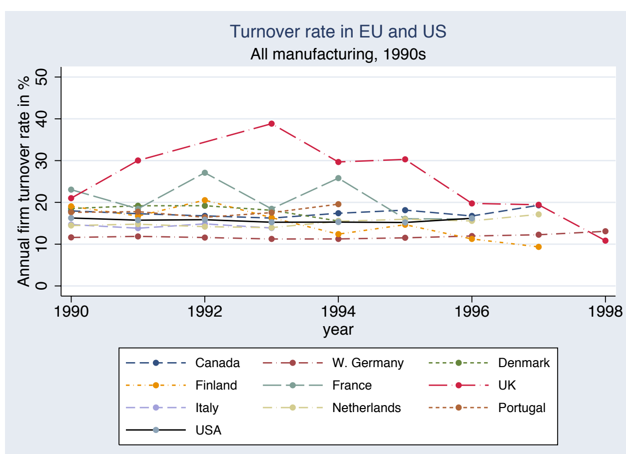


Figure 4: Turnover in EU countries and the US

Sources: Bartelsman, Haltiwanger and Scarpetta (2005), and author's calculations

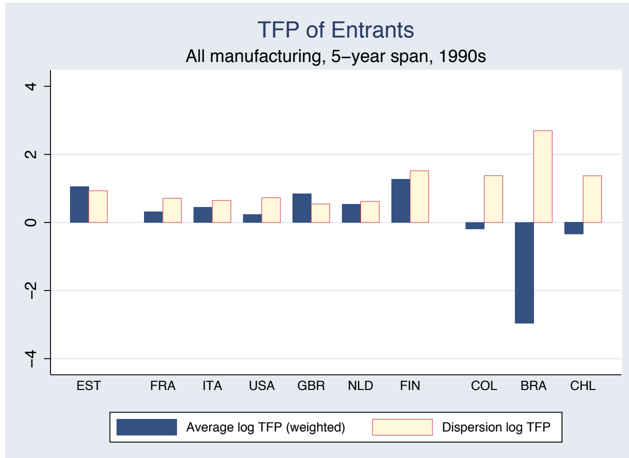


Figure 5: Productivity of entering firms

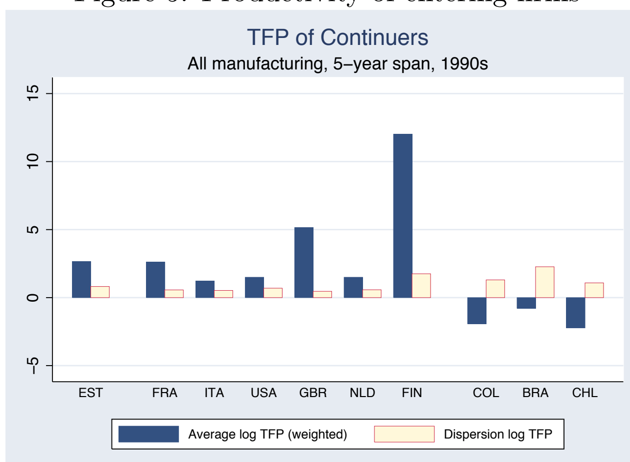


Figure 6: Productivity of continuing firms

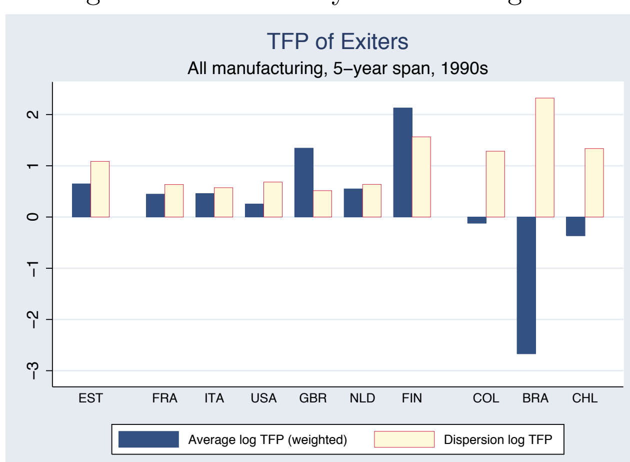


Figure 7: Productivity of exiting firms

Source: Bartelsman, Haltiwanger and Scarpetta (2005)

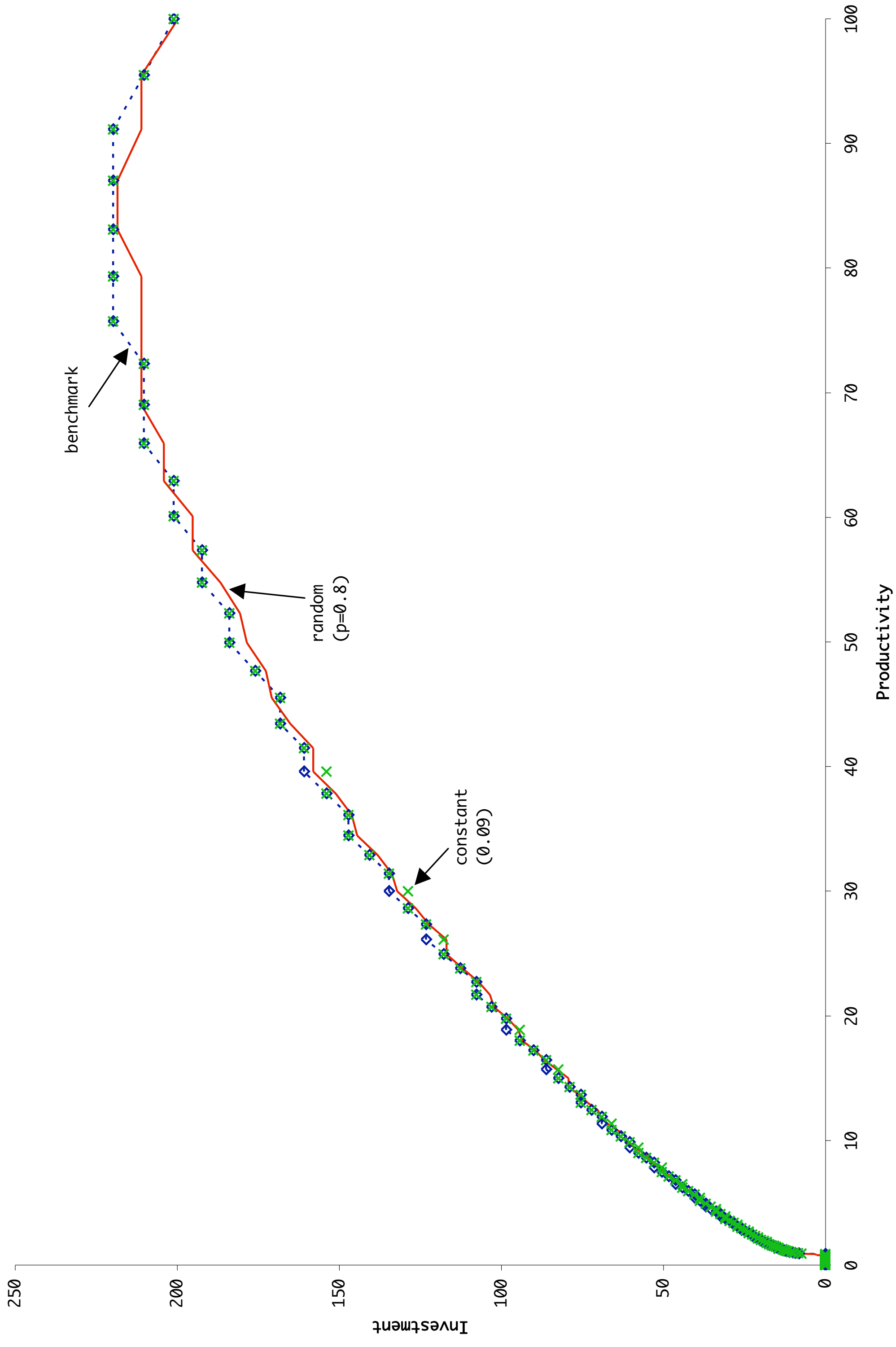


Figure 8: Investment Rule

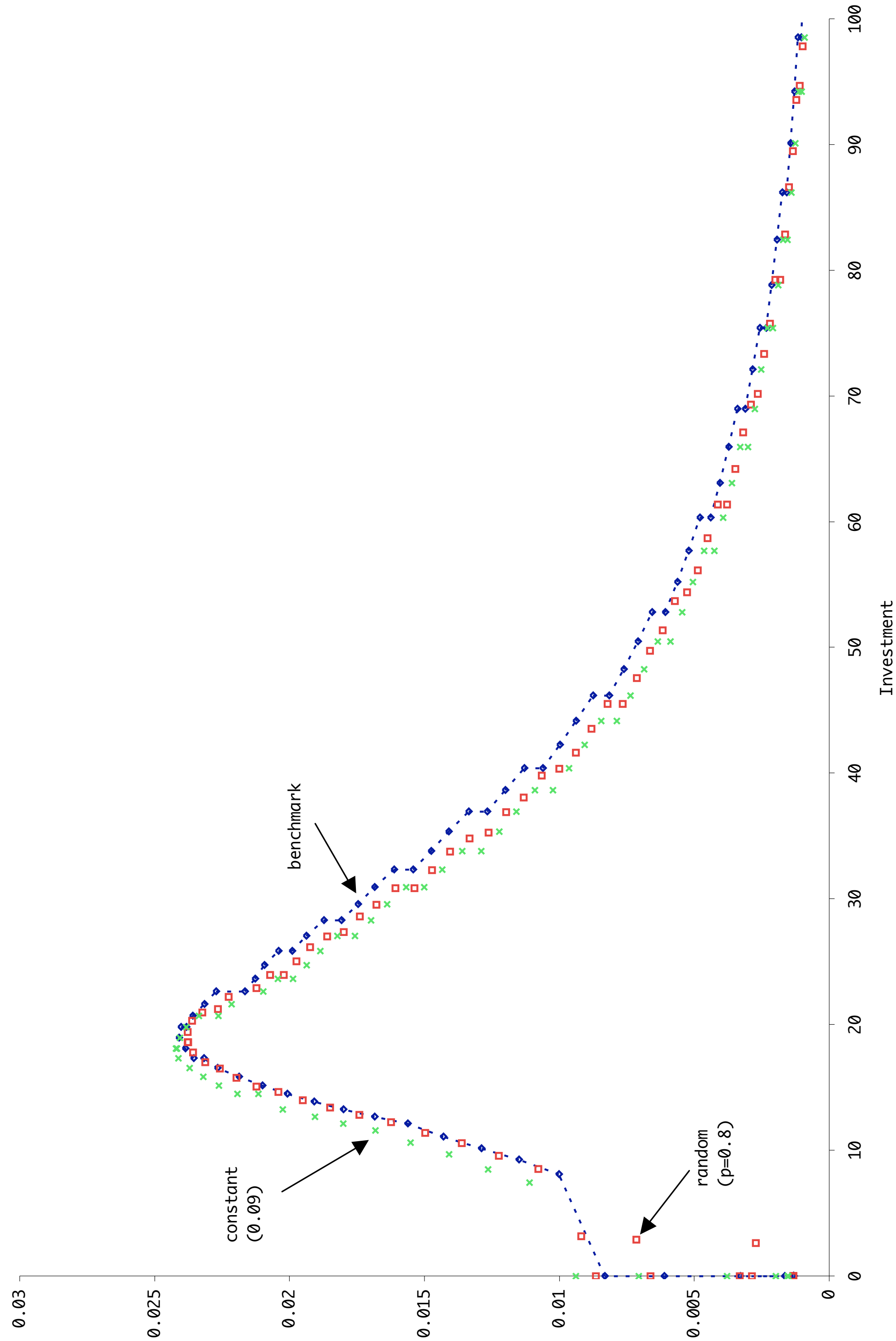


Figure 9: Investment Distribution

Table 1: TFP across countries

TFP for entrants - 5 year span

Country	Unweighted mean	Weighted mean	Dispersion
Brazil	-1.11	-2.24	2.46
Chile	-0.45	-0.12	1.20
Colombia	-0.95	-0.15	1.14
Estonia	4.16	1.56	0.82
Finland	10.13	1.55	1.51
France	3.20	0.36	0.59
UK	6.12	0.92	0.51
Italy	2.05	0.50	0.57
Netherlands	2.47	0.68	0.40
USA	2.02	0.34	0.64

TFP for continuers - 5 year span

Country	Unweighted mean	Weighted mean	Dispersion
Brazil	-0.06	-0.49	2.31
Chile	-1.04	-1.44	0.99
Colombia	-0.73	-1.21	1.09
Estonia	4.05	2.56	0.73
Finland	11.54	11.83	1.70
France	3.12	2.73	0.40
UK	6.15	5.34	0.45
Italy	1.85	1.33	0.41
Netherlands	2.49	1.81	0.39
USA	2.04	1.88	0.61

TFP for exiters - 5 year span

Country	Unweighted mean	Weighted mean	Dispersion
Brazil	-0.95	-2.24	2.24
Chile	-0.98	-0.24	1.17
Colombia	-0.38	-0.09	1.16
Estonia	3.85	1.29	0.99
Finland	10.28	2.19	1.76
France	3.20	0.45	0.52
UK	6.05	1.45	0.49
Italy	1.69	0.51	0.47
Netherlands	2.34	0.72	0.43
USA	1.96	0.34	0.60

Source: Bartelsman, Haltiwanger and Scarpetta (2005)

Table 2: TFP relative to the U.S.

	Entrants			Continuers			Exiting		
	mean	sd	cv	mean	sd	cv	mean	sd	cv
Brazil	-12.581	3.715	12.969	-0.534	3.273	8.668	-10.454	3.402	9.392
Chile	-1.440	1.889	2.758	-1.491	1.562	1.954	-1.439	1.958	2.876
Colombia	-0.810	1.894	2.775	-1.291	1.879	2.680	-0.478	1.882	2.674
Estonia	4.488	1.282	1.440	1.771	1.177	1.262	2.538	1.591	2.009
Finland	5.380	2.090	3.346	8.037	2.528	4.767	8.335	2.293	3.868
France	1.321	0.983	0.976	1.745	0.814	0.759	1.752	0.930	0.905
UK	3.581	0.751	0.679	3.442	0.669	0.590	5.265	0.755	0.688
Italy	1.895	0.891	0.854	0.815	0.761	0.694	1.797	0.839	0.790
Netherlands	2.264	0.851	0.803	1.001	0.831	0.779	2.152	0.934	0.911
USA	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Mean TFP corresponds to input-weighted mean of log TFP, calculated as explained in the appendix. The standard deviation (sd) is the simple standard deviation of log TFP, and the coefficient of variation (cv) is the ratio of the standard deviation to the mean of TFP (level) across firms. Source: Bartelsman, Haltiwanger and Scarpetta (2005) and author's calculations.

Table 3: Parameters for benchmark model

Fixed operating cost c_f	0.9500
Bankruptcy cost ϕ	-2.0000
	(-0.4634 in output units)
Entry cost c_e	0.9000
Investment cost c_x (constant)	0.0850
	(0.0197 in output units)
Labor cost share α	0.5000
Discount factor β	0.9500

Idiosyncratic shock process	
μ_ϵ	-5.3517
σ_ϵ (at $\bar{x} = 9.073$)	1.4987
At $\bar{x} = 9.073$	
$E(\epsilon)$	0.0142
$sd(\epsilon)$	0.0410
$E(s)$	1.2300
$sd(s)$	0.8800

Table 4: Comparison of basic statistics for the U.S. and benchmark model

A: Turnover and productivity distribution

	U.S.	**Model**
Innovative investment as a share of sales	3.74%	3.28%
Turnover rate	15.7813	15.6945
Coefficient of variation of entering firms*	1.0155	1.2746
Coefficient of variation of continuing firms*	0.9400	1.1087
Coefficient of variation of exiting firms*	0.9295	0.9131

B: Size Distribution

	< 20	20-49	50-99	100-499	> 500
U.S.					
Firms	0.726	0.151	0.061	0.049	0.012
Employment	0.067	0.068	0.063	0.145	0.657
Model					
Firms	0.489	0.212	0.113	0.148	0.039
Employment	0.031	0.058	0.067	0.263	0.581

*The coefficient of variation is the standard deviation of productivity s across firms, divided by the mean across firms. As in the data, the mean and standard deviation of productivity are calculated for entering, continuing, and exiting firms at 5-year spans. See the Appendix for details about the calculations.

Table 5: Statistics for alternative costs

	Benchmark 0.085	Constant 0.09	Random [0.075,0.095]	Random [0.065,0.09]
Price	100	102.662	98.997	98.631
Firm turnover rate	100	114.905	99.913	100.436
Average overall productivity	100	93.418	98.935	96.314
Coefficient of variation productivity	100	102.022	100.688	101.796
Average size of firms (Employment)	100	94.255	96.708	92.162
Average investment	100	92.589	98.782	95.866
Dispersion of investment	100	96.772	102.532	103.368

Table 6: Simulation results

Productivity	Benchmark 0.085	Constant 0.09	Random [0.075,0.095]	Random [0.065,0.09]
Entering				
Average	100	97.140	98.123	97.201
Dispersion	100	99.925	100.545	100.303
Continuing				
Average	100	96.354	99.617	95.506
Dispersion	100	100.402	98.780	98.476
Exiting				
Average	100	98.153	95.970	92.876
Dispersion	100	101.502	99.713	98.053

Investment	Benchmark 0.085	Constant 0.09	Random [0.075,0.095]	Random [0.065,0.09]
Entering				
Average	100	93.626	97.392	96.441
Dispersion	100	102.527	105.327	107.394
Continuing				
Average	100	95.345	99.167	95.380
Dispersion	100	102.744	104.395	109.036
Exiting				
Average	100	91.656	83.506	73.312
Dispersion	100	102.720	116.743	128.697

Table 7: Size distribution

	< 20	$20 - 49$	$50 - 99$	$100 - 499$	> 500
Benchmark (cost = 0.085)					
Firms	0.4895	0.2117	0.1127	0.1476	0.0385
Employment	0.0311	0.0581	0.0669	0.2625	0.5814
Constant cost = 0.09					
Firms	0.5009	0.2096	0.1224	0.1296	0.0375
Employment	0.0318	0.0584	0.0775	0.2472	0.5851
Random cost [0.075,0.095]					
Firms	0.4959	0.2102	0.1113	0.1448	0.0378
Employment	0.0315	0.0584	0.0669	0.2609	0.5823
Random cost [0.065,0.09]					
Firms	0.5117	0.2058	0.1076	0.1387	0.0361
Employment	0.0330	0.0594	0.0674	0.2601	0.5801