Employment protection, firm selection, and growth[*]

Markus Poschke[†]

September 2009

Abstract

How do firing costs affect aggregate productivity growth? To address this question, a model of endogenous growth through selection and imitation is developed. It is consistent with recent evidence on firm dynamics and on the importance of reallocation for productivity growth. In the model, growth is driven by selection among heterogeneous incumbent firms and is sustained as entrants imitate the best incumbents. In this framework, firing costs not only induce misallocation of labor, but also affect growth by affecting firms' exit decisions. Importantly, charging firing costs only to continuing firms raises growth by promoting selection. Also charging them to exiting firms is akin to an exit tax, hampers selection, and reduces growth – by 0.1 percentage points in a calibrated version of the model. With job turnover very similar in the two settings, this implies that the treatment of exiting firms matters for growth. In addition, the impact on growth rates is larger in sectors where firms face larger idiosyncratic shocks, as in services. This fits evidence that recent EU-U.S. growth rate differences are largest in these sectors and implies that firing costs can play a role here.

JEL codes: E24, J63, J65, L11, L16, O40

Keywords: endogenous growth theory, firm dynamics, labor market regulation, firing costs, entry and exit, firm selection

---

[*] I would like to thank the editor Robert King and an anonymous referee for substantial and detailed comments. I would also like to thank Omar Licandro, Alain Gabler, Andrea Ichino, Winfried Koeniger, Claudio Michelacci, Salvador Ortigueira, Josep Pijoan, Morten Ravn, Gilles Saint-Paul, Roberto Samaniego, Thijs van Rens, Jaume Ventura, and seminar participants at Cornell University, McGill, HEC Montréal, Pompeu Fabra University, CEMFI Madrid, London Business School, Southampton, Mannheim, Universitat Autonoma de Barcelona, Alicante, Berne, HEC Paris, Southern Methodist University, Central European University, the European University Institute, the Econometric Society European Winter Meeting (2006), the XI Workshop on Dynamic Macroecomics in Vigo (2006), the Society for Economic Dynamics 18th meeting (2007), and the IZA-EUI Workshop on Firm Dynamics, Labor Markets and Growth (2007) for valuable comments and discussions.

[†] McGill University and IZA. e-mail: markus.poschke@mcgill.ca.

1 Introduction

How do firing costs affect the growth rate of aggregate productivity? Research has focussed on their impact on the level of productivity or on employment. To evaluate the growth effect, a heterogeneous-firm model with endogenous growth is developed. Besides being consistent with recent evidence on firm dynamics and on the importance of reallocation for productivity growth, the model can also account for the fact that recent productivity growth differences between the U.S. and the EU were particularly strong in the service sector. Employment protection legislation (EPL) here does not only affect the efficiency of the allocation of labor across plants or the incentive to work or to search as in most of the existing literature, but also affects the endogenous growth of aggregate productivity through its impact on the market selection process through the entry and exit margins.

Recent empirical research on firm dynamics has highlighted the importance of entry and exit and the heterogeneity of firms and plants. For example, Dwyer (1998) finds that productivity differs by a factor 3 between establishments in the 9th and the 2nd decile of the productivity distribution in the U.S. textile sector. Foster, Haltiwanger and Krizan (2001) (FHK) find that in the U.S. Census of Manufactures, more than a quarter of the increase in aggregate productivity between 1977 and 1987 was due to entry and exit. This is even more pronounced in the retail sector, as they find in their (2006) paper. The contribution of exit to aggregate productivity is positive in almost all of the 24 industrial and developing countries analyzed by Bartelsman, Haltiwanger and Scarpetta (2004) (BHS). Gabler and Licandro (2006) and Luttmer (2007) find in calibration exercises that around half of U.S. post-war productivity growth can be traced to the process of market selection, entry, and exit.[1]

The importance of entry and exit varies across industries. Generally, they contribute more to growth in sectors with high turbulence and with high TFP growth (BHS). These sectors,

---

[1] For more on methods and results on firm-level dynamics see also Haltiwanger (1997), Bartelsman and Doms (2000) and Bartelsman, Scarpetta and Schivardi (2003).

in particular services, were precisely the ones where Europe lagged U.S. productivity growth in recent years (Blanchard 2004). Theory suggests that EPL imposes tighter constraints on firms in these more turbulent sectors (see e.g. Bentolila and Bertola 1990). Indeed, Pierre and Scarpetta (2004) show that innovative firms feel particularly constrained by EPL. These pieces of evidence suggest the following account: productivity growth is higher in high-turbulence industries. In these industries, EPL constrains firms more strongly. With stricter EPL in continental Europe compared to the U.S., this fits the pattern of recent productivity growth differences showing up particularly in the service sector.[2]

This paper takes this evidence as a point of departure. The mechanism of growth through selection and experimentation developed here fits many facts on firm dynamics and introduces a relationship between turbulence and growth. Most importantly, it allows quantifying the effect of firing costs along several margins, including their growth effect via entry, exit, and selection. The basic model is similar to the ones developed in Gabler and Licandro (2006) and Luttmer (2007). In its treatment of firing costs, the analysis is related to the seminal paper by Hopenhayn and Rogerson (1993), and the more recent ones by Alvarez and Veracierto (2001), Veracierto (2001), and Samaniego (2006a). These four all analyze the effect of firing costs on the level of aggregate productivity. They employ a setting of exogenous growth and concentrate on the static efficiency of the allocation of labor. Bertola (1994), conversely, analyzes the effect of hiring and firing costs on growth, using a model of endogenous growth through variety expansion. In such a setting, firing costs affect entry but not exit, so that the selection effect that is crucial here cannot arise.

In the model developed here, firms receive idiosyncratic productivity shocks and therefore differ in their productivity. Growth arises and is sustained endogenously through the inter-

---

[2] Additional effects can arise through specialization, as argued by Saint-Paul (2002). Scarpetta, Hemmings, Tressel and Woo (2002) find that industries with wider productivity dispersion have higher average productivity. Cuñat and Melitz (2007) provide evidence that high-EPL countries tend to specialize in low-dispersion industries, avoiding the industries where EPL has more bite. Similarly, Samaniego (2006b) analyzes how EPL can constrain technology adoption and shape specialization patterns in the presence of exogenous embodied technical progress. Gust and Marquez (2004) establish an empirical link between EPL and lower growth that passes through lower use of information technology.

action of selection (among incumbents) and imitation (by entrants). Each period, the least productive incumbents are eliminated, implying that the average productivity of remaining firms grows. Entry sustains growth: Entrants try to imitate firms close to the technological frontier. They do not succeed fully, but on average enter a constant fraction below it. Hence, there is a spillover from incumbents to entrants through the location of the frontier. How much the economy benefits from it depends on how much entry and exit, and thus selection, there is, so growth is driven by both selection and imitation. In addition, growth depends on the variance of productivity shocks. A higher variance, as observed in the service sector, makes high productivity draws more likely. While it also makes very low draws more likely, these are cut off by subsequent exit. As a result, selection is stricter, and growth is faster.

In this context, labor market regulation affects the entry and exit incentives of firms, and thereby the engines of growth in this model. It is well-known that firing costs, as one-sided adjustment costs, lead to an inefficient allocation of labor and lower aggregate productivity. Firm value is also lower, which is the mechanism reducing entry and growth in Bertola (1994).

In the present paper, there is an additional effect through exit and selection. To analyze it, it is crucial to distinguish if exiting firms have to pay firing costs or are exempt. This distinction is also made by Samaniego (2006a) in an environment of exogenous growth. The crucial observation is that firing costs have two distinct effects: they are not only an adjustment cost but also a tax on exit. The latter discourages exit of low-productivity firms, thereby weakens the selection process, and reduces productivity growth through selection. When exiting firms are exempt, however, firing costs lower a firm's continuation value relative to the value of exit, thereby promoting exit of low-productivity firms, strengthening selection, and increasing growth relative to the frictionless economy. Both effects are stronger when the variance of idiosyncratic shocks is larger – so EPL has a stronger effect on growth in the service sector.

To quantitatively evaluate the impact of labor market regulation on observed differences in productivity growth, the model is calibrated to the U.S. business sector. Then the effects of introducing firing costs of one year's wages, close to the level observed in many continental European countries, is evaluated. Results show that charging firing costs only to continuing firms promotes selection and raises growth by 0.1 percentage points.[3] Charging them to exiting firms, too, reduces growth by the same amount compared to the benchmark, showing that the treatment of exiting firms is crucial for the growth effects of EPL. These effects are larger in the service sector. Job turnover always drops significantly, and only marginally more when charging exiting firms. This suggests that even when there are technological costs of job turnover such as search frictions (which are not modelled here), achieving this small additional reduction in job turnover is probably not worth its cost in terms of lower growth.

To summarize, the paper makes two main contributions. Firstly, it provides a growth model that is consistent with facts on firm dynamics and highlights the role of selection. Secondly, it provides a theoretical analysis of the effect of firing costs on productivity growth. Charging firing costs to exiting firms reduces growth by hampering selection, with only a small additional reduction in job turnover. This shows that inhibiting the market selection mechanism comes at a cost.

The paper is organized as follows. In the next section, a simple heterogeneous firm model with growth by selection and experimentation is set up. In Section 3, it is solved for optimal behavior of all agents, equilibrium is defined, and the determination of the growth rate is discussed. In the following section, the model is calibrated, and in Section 5, the quantitative effects of firing costs are explored. Section 6 concludes.

2 The model economy

Time is discrete and the horizon infinite. The economy is populated by a continuum of infinitely-lived consumers of measure one, a continuum of active firms of endogenous measure

---

[3] This does not imply that firing costs enhance welfare. It can be shown that, comparing balanced growth paths, gains from the higher growth rate are outweighed by negative level effects.

and a large pool of potential entrants.

Consumers. Consumers value consumption and dislike working; this is summarized in the period utility function $u(c_t, n_t) = \ln c_t - \theta n_t$. They discount the future using a discount factor $\beta < 1$. They can consume or invest in shares of active and entering firms. Denoting holdings of the optimal diversified portfolio by a_t and the net return to it by r_t, their budget constraint is $c_t + a_{t+1} = w_t n_t + (1 + r_t)a_t$.

Firms: Firms produce a homogeneous good using labor as their only variable input, with a positive and diminishing marginal product. This good serves as the numéraire of the economy. To remain active, firms also incur a fixed operating cost ϕ_t^f each period; this grows over time at the growth rate of output, g.

Firms differ in productivity. This arises because each firm receives idiosyncratic productivity shocks; more precisely, its log productivity follows a random walk. This is a very simple way of capturing the role of idiosyncratic shocks established by the empirical literature. It also renders the persistence of firm level productivity found in the data.[4] The production technology can then be summarized in Assumption 1 and in the production function $y_{it} = \exp(s_{it})n_{it}^{\alpha}$, $0 < \alpha < 1$, where y_{it} denotes output of firm i in period t, $\exp(s_{it})$ is its productivity level, and n_{it} employment.

Assumption 1 *Log productivity evolves according to* $s_{it} = s_{i,t-1} + \epsilon_{it}$, *with* $\epsilon \sim N(0, \sigma^2)$.

What is crucial about this assumption is that a firm's productivity is not stationary.[5]

---

[4] Empirical work on firm dynamics agrees on the importance of idiosyncratic shocks to firm-level productivity. Without going to a detailed dynamic analysis of firm-level data, this can be inferred from the high correlation of contemporaneous entry and exit rates for most industries (this does not fit well with aggregate or industry-level shocks as main driver of firms' fate), from the fact that productivity differences among firms are larger within than between industries (FHK), and from the fact that there are frequent changes in the identity of industry leaders. Recent evidence in favor of a random walk as the main driver of firms' productivity is provided by Franco and Philippon (2007).

[5] While the random walk could be tweaked to also fit deviations from Gibrat's law (the independence of firm growth rates and size) that have been found in the data, this would not substantially alter the growth mechanism.

Firing costs: Adjusting employment is costless in the benchmark case. This will be compared to the case with employment protection legislation (EPL) in the form of firing costs of ψ times a period's wages for each worker fired. This policy can take two forms, one where firing costs always have to be paid when firing a worker, including upon exit (denoted by $F_x = 1$), and another one where firing costs only have to be paid if the firm also remains active in the subsequent period; i.e. exiting firms are exempted from firing costs (denoted by $F_x = 0$). An active firm's profit function can then be written as

$$\pi_{it} = \pi(s_{it}, n_{it}, n_{i,t-1}, w_t) = \exp(s_{it})\; n_{it}^{\alpha} - w_t n_{it} - \phi_t^f - h(n_{it}, n_{i,t-1}), \tag{1}$$

where w_t denotes the period-t wage and the function $h(n_{it}, n_{i,t-1})$ summarizes firing costs. Assuming that there are no quits, it is given by

$$h(n_{it}, n_{i,t-1}) = \psi w_t \cdot \begin{cases} \max(0, n_{i,t-1} - n_{it}) & \text{if } F_x = 1 \vee (F_x = 0 \wedge n_{it} > 0), \\ 0 & \text{if } F_x = 0 \wedge n_{it} = 0. \end{cases}$$

The dependence of $h(\cdot)$ on previous period's employment makes the employment choice a dynamic decision and implies that a firm's individual state variables are $(s_{it}, n_{i,t-1})$.

At the beginning of any period, firms can decide whether to exit at the end of that period. This is costless in the benchmark case and when exiting firms are exempt from firing costs ($F_x = 0$); otherwise ($F_x = 1$) the exiting firm has to cover the firing cost for reducing its workforce from $n_{i,t-1}$ to 0.

Entry: Entering firms have to pay a sunk entry cost ϕ_t^e that grows at the same rate as output. This can be interpreted as an irreversible investment into setting up production facilities. Entrants try to imitate the best firms in the economy; for the sake of concreteness, assume that they identify the best 1% of firms with the frontier of the economy. Denote average productivity of the target group with $s_t^{\max}$. In practice, entrants are on average less productive than incumbents; for instance, FHK report that active firms that entered within the last 10 years are on average 99% as productive as incumbents. One possible explanation is that they cannot copy incumbents perfectly due to tacitness of knowledge embodied in these firms. Assumption 2 formalizes the imitation process. (See Figure 1 for an illustration.)

Assumption 2 *Entrants draw their initial log productivity* s_{it}^0 *from a normal distribution with mean* $s_t^{\max} - \kappa$ *(*$\kappa > 0$*) and variance* σ_e^2*. Denote its pdf by* $\eta_t(s^0)$*.*

The assumption implies that, as the distribution of incumbents moves rightward, the distribution of entrants' log productivity tracks it at a constant distance κ. Because $\kappa > 0$, entrants are on average less productive than the best incumbents. In the configuration depicted in Figure 1, entrants are on average less productive than the average incumbent while entering into all deciles of the productivity distribution, as suggested by the data.

Assumption 2 describes an externality; incumbents' productivity spills over to entrants. Together with the selection process, this externality drives growth. It can be interpreted in other ways besides imitation. For instance, incumbents' productivity is an indicator of knowledge in the economy. If entrants can draw on that, either as a spillover or because it is embodied in the production facilities they acquire upon entry, they benefit from incumbents' productivity.

The intensity of experimentation, parametrized by σ_e^2, influences the growth process. A higher σ_e^2 implies that the probability of drawing an extreme, including very high, productivity increases. On the other hand, the higher probability of bad draws means that the entry process consumes more resources, making the net effect ambiguous.

Let $\tilde{\mu}(s, n_{-1}) \equiv M\mu(s, n_{-1})$ be the measure of firms with states (s, n_{-1}), where M is the number of firms in the economy, and $\mu(s, n_{-1})$ is a density function. The assumption of a continuum of firms that are all independently affected by the same stochastic process, together with the absence of aggregate uncertainty, implies that the aggregate distribution evolves deterministically. As a consequence, although the identity of firms with any (s, n_{-1}) is not determined, their measure is deterministic. Moreover, the underlying probability distributions can be used to describe the evolution of the cross-sectional distribution.

Timing: The structure of the economy implies the following timing. At the beginning of any period, firms decide if they stay or exit, and potential entrants decide whether to enter. All firms that stay or enter pay the fixed operating cost ϕ_t^f, and entrants in addition pay the entry cost ϕ_t^e. Then incumbent firms receive their productivity innovations and entrants draw their initial productivity. Firms demand labor, workers supply it, and the wage adjusts to clear the labor market. Production occurs, agents consume, and profits are realized. Firms that reduced labor or exited pay the firing cost. After this, the whole process resumes. Hence, the dynamic choices of entry, exit, and employment are all made based on firms' expectations of future productivity.

3 Equilibrium

This section starts with the derivation of optimal behavior for all agents. Then, equilibrium is defined, followed by a discussion of the balanced growth path, the selection mechanism and the determination of the growth rate.

3.1 Optimal behavior

Consumers maximize utility by choosing asset holdings and labor supply. Firms maximize the expected discounted sum of profits by choosing employment, entry, and exit. These decisions shape the law of motion of the firm productivity distribution, and thereby determine the growth rate.

Consumers: The consumer problem is completely standard. Utility maximization yields the Euler equation

$$\frac{c_{t+1}}{c_t} = \beta(1 + r_t). \tag{2}$$

Defining g^c as the growth rate of consumption, this implies that the prevailing gross interest rate in the economy is $1 + r_t = (1 + g^c_t)/\beta$. As consumers own firms, this intertemporal marginal rate of substitution is also used to value future profits. Consumers supply labor in accordance with the first order condition $c_t = w_t/\theta$.

Employment: Active firms face a standard dynamic optimization problem. This is particularly simple in the case with no firing costs, since then the employment choice is a sequence of static problems, and a firm's productivity s is the only firm-level state variable. With firing costs, last period's employment n_{-1} also becomes a state variable for the firm. The aggregate state variable is the firm productivity distribution μ. Together with firms' employment policies, it determines the labor-market clearing wage w, which is the aggregate state that matters for a firm. So denote the firm's employment policy for the problem with firing costs by $n(s, n_{-1}, w; \mu)$. The associated Bellman equation is

$$V(s, n_{-1}, w; \mu) = \max_{n} \left\{ \pi(s, n, n_{-1}, w) + \frac{1}{1+r} \max \left(\mathbb{E}[V(s', n, w'; \mu')|s], V^x \right) \right\}, \qquad (3)$$

where the inner max operator indicates the option to exit, V^x denotes the value of exit as detailed in (4) below, and primes denote next-period values. Note that, since aggregates are deterministic, the firm faces uncertainty only about its own future productivity s', not about future wages and firm distributions.

Existence and uniqueness of the value function follow from standard arguments. In addition, three properties carry over from the profit function: The value function is increasing and convex in s given n_{-1}, decreasing in w, and weakly decreasing in n_{-1} given s if there are firing costs. Whereas the employment policy $n(s, n_{-1}, w; \mu)$ increases monotonically in s in the frictionless economy, it features a constant part around n_{-1} when $\psi > 0$. This is a standard effect of non-convex adjustment costs. It is illustrated in Figure 2. The figure shows a firm's labor demand as a function of its current productivity, given a past level of employment of n_{-1}. Intuitively, when the optimal level of employment in the frictionless case is only slightly higher than n_{-1}, the firm will not immediately raise employment because productivity might fall again, and reducing employment again then would be costly. Analogously, when a firm's productivity falls slightly, it will not immediately fire workers because productivity might recover and it would have paid the firing cost prematurely. When firms are exempted from paying the firing cost upon exit ($F_x = 0$), firms that suffer a negative productivity shock so large that they are forced to exit will not adjust employment downward immediately, but keep it constant and fire all workers upon exit, thus avoiding the firing cost. So given an n_{-1}, the employment policy is constant for s very low or around n_{-1}, and strictly increasing elsewhere. Denoting the domains of s and n_{-1} with S and N respectively, the employment policy function and the law of motion for s then jointly define a transition probability function $q : (S \times N) \times (S \times N) \rightarrow [0, 1]$ that gives the probability of going from state (s, n_{-1}) to state (s', n). Clearly, q depends on w and μ; these arguments are omitted for simplicity.

Exit: Firms exit if the expected value of continuing conditional on current states is less than that of exiting. The latter is equal to firing costs due if these have to be paid upon exit, and zero otherwise:

$$V^x = -F_x \psi\, w\, n = \begin{cases} 0 & \text{if } \psi = 0 \vee F_x = 0, \\ -\psi\, w\, n & \text{if } F_x = 1. \end{cases} \tag{4}$$

Exit and re-entry also yields zero net value due to free entry – see equation (6) below. V^x is thus constant in s. Since V is strictly increasing in s for any n_{-1}, there is a unique threshold s_x where the expected value of continuing equals the value of exit. Firms exit when they draw an s below this. The exit threshold then is a function of n_{-1}, w', and μ', defined by

$$s_x(n_{-1}, w'; \mu') = \{s | \mathbb{E}[V(s', n, w'; \mu')|s] = V^x\}. \tag{5}$$

The dependence of the exit threshold on the other variables is crucial for the selection effect. Clearly, s_x increases in w'. It also increases in the future productivity of other firms, μ'. As the value function is weakly decreasing in n_{-1}, the exit threshold is weakly *in*creasing in it. Finally, with firing costs upon exit, the value of exit is lower, and so is the exit threshold. In this sense, firing costs on exiting firms act as a tax on exit and discourage exit, particularly of low-productivity firms.

Entry: Potential entrants enter until the expected net value of doing so is driven to zero. So in equilibrium, the free entry condition

$$\mathbb{E}[V^e(s^0, w_t; \mu_t)] = \phi_t^e \tag{6}$$

holds. (Alternatively, if $\mathbb{E}[V^e(s^0, w_t; \mu_t)] < \phi_t^e$, no entry takes place.) Since ϕ_t^e and the distribution of s^0 are exogenous features of technology, this equation pins down the wage, given a firm distribution. A wage below (above) its equilibrium value would trigger additional (reduced) entry, driving up (down) the wage.

All firms' decisions combined and the process for idiosyncratic shocks yield the law of motion for the firm productivity distribution $\mu(\cdot)$

$$\mu'(s,n) = \begin{cases} \int_N \int_{s_x(n_{-1})} \mu(u, n_{-1})\, q(s, n|u, n_{-1})\, \mathrm{d}u\, \mathrm{d}n_{-1} & \text{if } n > 0, \\ \eta(s^0 = s)/M & \text{if } n = 0 \end{cases} \tag{7}$$

with firing costs, and simply $\mu'(s) = \int_{s_x} \mu(u)\, q(s|u)\, \mathrm{d}u + \eta(s^0 = s)/M$ otherwise. In both cases, the integral describes the motion of incumbents. Exit is captured by the restriction of the domain of the integral to surviving firms, and entry is given by $\eta(\cdot)$. All elements for analyzing equilibrium of this economy have been assembled now. The next steps now are to define a competitive equilibrium, describe briefly how to compute its balanced growth path, and analyze the determination of the growth rate.

Equilibrium definition: A competitive equilibrium of this economy consists of sequences of the real wage w_t, the number of firms M_t and the firm productivity density $\mu_t(s, n_{-1})$ and of firm policy and value functions $n(s, n_{-1}, w; \mu)$, $s_x(n_{-1}, w; \mu)$ and $V(s, n_{-1}, w; \mu)$ such that consumers and firms behave optimally, taking aggregates as given, the free entry condition holds, the labor market clears, and the firm distribution is defined recursively by equation (7) given μ_0, M_t and s_{xt}. This last condition implies that the sequence of firm distributions is consistent with the law of motion generated by the entry and exit rules. The rest of the paper will deal only with balanced growth equilibria.

3.2 Balanced growth

Define a balanced growth equilibrium or balanced growth path (BGP) as a competitive equilibrium in which output, consumption, wages, and aggregate productivity grow at a constant rate g, the firm log productivity distribution shifts up the productivity scale in steps of g, its shape is invariant, and the firm employment distribution, the interest rate, the number of firms, the firm turnover rate, and other dynamic characteristics of the firm distribution are constant. In this case, the economy can be made stationary by applying the transformation $\hat{z}_t = z_t e^{-gt} = z$ to all growing variables z, $\hat{x}_t = x_t = x$ to all constant variables x, and $\hat{s}_{it} = s_{it} - gt$ to the firm-level productivity state. (In the following, I will refer to the "transformed" as opposed to the "growing" economy. To distinguish them, the transformed variables carry hats. Note that the transformation of s also affects the transition function q.) So in the transformed economy, firm productivity evolves according to

$$\hat{s}_{it} = \hat{s}_{i,t-1} - g + \epsilon_{it}.$$

The random walk gets a downward drift (for positive aggregate growth rates) because the whole firm productivity distribution shifts up at rate g, so in expectation, firms fall back by g every period relative to the distribution. For an individual firm, being in a fast-growing economy – an economy where other firms grow fast – thus implies a more quickly declining profile of relative productivity. With wages growing at a rate g, this translates into a faster decline of expected profits. In short, the more quickly the economy grows, the more fast-paced and hostile the environment firms face.

On a balanced growth path, firms do not need to keep track of the entire productivity distribution; g and $\hat{w}$ are sufficient statistics for the path of future wages. They are pinned down by the free entry condition and the law of motion of the productivity distribution. Using the transformed variables, the free entry condition becomes

$$\mathbb{E}[V^e(\hat{s}^0, \hat{w}; g)] = \phi^e. \tag{E}$$

The solid line labeled E in Figure 3 depicts the combinations of $\hat{w}$ and g for which this condition holds, given entrants' productivity distribution η and the entry investment ϕ^e. A higher level of wages reduces the expected level of profits, while a higher growth rate implies that profits are expected to fall faster, both reducing firm value and the value of entry. As a consequence, the pairs of $\hat{w}$ and g consistent with a constant expected value of entry as required by (E) trace out a downward-sloping line.

Substituting the law of motion of the productivity distribution (for simplicity, for the case without firing costs) into the balanced growth restriction $\hat{\mu}' = \hat{\mu}$ yields

$$\hat{\mu}'(\hat{s}) = \int_{\hat{s}_x} \hat{\mu}(u)\, \hat{q}(\hat{s}|u)\, \mathrm{d}u + \eta(\hat{s}^0 = \hat{s})/\hat{M} = \hat{\mu}(\hat{s}) \tag{S}$$

for all $\hat{s}$. On a balanced growth path, entry, exit, and growth interact in such a way as to keep the transformed distribution $\hat{\mu}$ constant. The combinations of $\hat{w}$ and g (implicit in (S) through $\hat{s}_x$ and $\hat{q}$) that satisfy the law of motion and the balanced growth restriction trace out the upward-sloping solid line in Figure 3. Refer to it as the selection line, labeled S. It is upward sloping because a higher wage raises the exit threshold $\hat{s}_x$, thereby makes selection tougher, forces more low-productivity firms to exit each period, and increases average productivity of the remaining firms, thus implying a higher growth rate. Intuitively, stricter selection raises the upper bound of the tail of low-productivity firms that exit every period. This results in a larger productivity difference between the set of firms that start a period and those that survive it, and in the replacement of more low-productivity firms by better entrants. Through these channels, any factor that raises the exit threshold and thus makes selection tougher promotes growth.

The intersection of the two curves gives the equilibrium growth rate and transformed wage on the BGP. With this g and $\hat{w}$, the net value of entry is zero, entry and exit take place, and the transformed distribution $\hat{\mu}$ is constant. The shape of the curves ensures that this pair exists and is unique. The online appendix describes how to compute this equilibrium.[6]

3.3 The growth rate

The growth rate g is driven by the selection process and by the distance κ between entrants' and incumbents' mean productivity. Intuitively, the process is as follows. In the growing economy, the productivity of incumbents follows a random walk. This implies that for a given set of firms, each firm's productivity is constant in expectation, but the variance of those firms' productivity distribution grows over time. However, with exit, the exit threshold truncates the firms' productivity distribution from below. As a result, the distribution can only expand upwards, and average productivity of this set of firms grows. In this way, with the most productive firms surviving, selection drives growth. While this process bears some similarity to the one in Jovanovic (1982), there is also a crucial difference: Whereas in Jovanovic (1982), firms gradually discover their underlying, given productivity, in the present case firms' productivity actually evolves over time. Selection hence is not just a process of passive discovery of the most productive, but is active, driven by changes at the firm level.

As time goes by and firms keep on exiting, the distribution thins out. This is why entry

---

[6] One conceptual concern here is to ensure that starting with some initial productivity distribution, the variance of the distribution remains finite as time goes by, and is not blown up by the random walk in firms' productivity. Growth ensures this by making the weight of each cohort's contribution to aggregate variance decline faster than the within-cohort variance can rise due to the random walk. As a result, each cohort's contribution to aggregate variance declines as the cohort ages, and the variance of the aggregate productivity distribution is bounded. For a more detailed argument, see the online appendix.

is needed to sustain growth: In a stationary equilibrium, the measure of firms is constant, and exiting firms are replaced by entering ones. Yet while exiting firms are at the bottom of the distribution, entering firms are more productive – otherwise they would not enter. As a result, the productivity distribution shifts to the right: the bottom firms are replaced by more productive entrants, while some firms in the upper part of the distribution are lucky, receive positive shocks, and move that part of the distribution to the right.

For this process, both non-stationarity of individual firms' productivity and the dependence of entrants' average productivity on that of incumbents, i.e. both Assumptions 1 and 2, matter. Without the latter, say with entrants always drawing from the same distribution, selection would still have some effect. However, there would not be a balanced growth path of the type analyzed here, as the productivity distribution would fan out, and thin out, over time. Without the former assumption, the growth engine is choked off. Exogenous increases in entrants' productivity, resulting in a vintage-type model, could still yield a growth path similar to the one analyzed here, but with the crucial difference that all growth would result from entry and exit. This is at odds with the evidence.

4 Benchmark economy

To derive quantitative conclusions, we calibrate the model to the U.S. non-farm business sector. This is a good no-firing cost benchmark since both procedural inconveniences and severance pay due upon an individual no-fault dismissal are zero in the U.S. according to the OECD's indicators of employment protection published in Nicoletti, Scarpetta and Boylaud (2000). Other measures of employment protection are also among the lowest worldwide.

To calibrate the model, commonly used values from the literature are used for some baseline parameters, while the remaining ones are chosen jointly such that the distance between a set of informative model moments and corresponding data moments is minimized.[7]

---

[7] Distance is measured as the mean squared relative deviation. To find the global minimum of the objective function, a genetic algorithm is used.

An exception is κ, the productivity of entrants relative to the top incumbents. As no direct empirical evidence on it is available, it is set to exactly match the closest available empirical counterpart. This is the relative productivity of firms that entered within the last ten years. Foster et al. (2001) report it to be 99% of average productivity.

The parameter values adopted from the literature are 0.64 for the labor share α and 0.95 for the discount factor β. The disutility of labor θ is set such that labor force participation fits the value of 66% reported by the BLS and the ILO. The upper bound of the grid for s is chosen such that the largest plant has 1500 employees. According to U.S. Census Statistics of U.S. Businesses data reported by Rossi-Hansberg and Wright (2007), less than 0.05% of plants are larger than this.

The four parameters that remain to be assigned are the variance of the log productivity distribution of entrants, σ_e^2, the variance of the the idiosyncratic productivity shock hitting incumbents, σ^2, the fixed operating cost ϕ^f, and the entry cost ϕ^e. They are chosen to jointly match the job turnover rate, average plant size, the four-year survival rate of entrants, and the share of aggregate productivity growth due to entry and exit. These moments capture a rich set of aspects of the firm distribution and its dynamics.

Average plant size (26.4 employees in the U.S. business sector according to Bartelsman et al. 2003, Table 2) pins down ϕ^f and ϕ^e, given their ratio. The job turnover rate is driven to a large extent by the variance of productivity shocks. Defined as the sum of job creation and job destruction divided by employment, it is 28% yearly in the U.S. according to the BLS. Davis, Haltiwanger and Schuh (1996) document significant cross-country differences in this variable, with the U.S. value on the high side among developed economies.

Important statistics for understanding entry and its implications are entrants' survival rates and the share of growth due to entry and exit. Matching them ensures that the entry and selection process plays a quantitatively realistic role. Together, they are informative about σ_e^2 and ϕ^e. The four-year survival rate, i.e. the proportion of entrants of a given cohort still active four years later, is 63% in the U.S. (BHS, using the U.S. Census Longitudinal

Business Database). The share of productivity growth due to entry and exit is 26% for the U.S. manufacturing sector and higher in retailing according to Foster et al. (2001, 2006). Other studies find similar estimates, BHS give an overview. For the economy as a whole, the figure of 26% used here is hence a lower bound, implying that results related to selection obtained here are rather conservative. If selection is more important for growth than modeled here, factors influencing selection have a larger effect on growth than reported below.

[Tables 1 and 2 about here]

Calibration targets and model values are given in Table 1. Adopted parameter values are given in Table 2. Model statistics fit all targets closely. The calibration also fits reasonably well in dimensions that were not targeted. In particular, the productivity dispersion (TFP ratio of 85th to 15th percentile) falls comfortably within the range of 2 to 4 reported by Dwyer (1998) from U.S. data, and the seven-year growth rate of surviving entrants is close to the data moment of 40%. Hence, the shape of the distribution, its dynamic behavior, and entrants' performance match the data well.

Remarkably, the implied growth rate, without being targeted, is also of a reasonable magnitude. This occurs although, apart from the share of growth due to entry and exit and the standard preference and technology parameters, only "micro" or firm dynamics moments were targeted. Fitting these is important; e.g. raising σ^2 by 10% not only leads to a contribution of entry and exit to aggregate growth of 31% (quite a bit too large), but also to a much higher growth rate, at 2.9%. It thus seems safe to conclude that the model of growth through selection and experimentation presented here provides a good description of the way selection and reallocation promote growth in the U.S..

5 Firing costs and productivity growth

The objective of the paper is the analysis of the impact of firing costs on aggregate productivity growth. Since growth is endogenous in the model developed above, frictions can affect not only the level (as in previous literature), but also the growth rate of output and productivity. This section explores their effect first theoretically, then empirically.

5.1 Theoretical discussion

Firing costs affect firms in two ways: they constitute a friction to the adjustment of labor, and they are a tax on exit, if charged to exiting firms. As an adjustment friction, firing costs cause firms' employment to deviate from what is optimal in the frictionless economy. This reduces firm value and the incentive to enter or to continue in operation for any $\hat{w}$ and g. For the free entry condition (E) to hold, $\hat{w}$ must then be lower for any g, and the free entry curve E shifts left. (See the dashed and dotted lines in Figure 3.) Because most exiting firms are small and firing costs have their main effect on continuing firms, this shift is quantitatively similar no matter how exiting firms are treated.

Firing costs also affect firms' exit decisions. If they are charged only to continuing firms ($F_x = 0$), the value of exit is the same as in the benchmark economy. Because firing costs still reduce the value of continuing, the exit threshold $\hat{s}_x$ rises. Just as in the construction of the selection line in Section 3.2, a higher exit threshold implies stricter selection, the exit of more low-productivity firms, and a higher growth rate for any fixed $\hat{w}$. Stricter selection moves the selection line S up to the dashed line. Together with the shift in the entry curve, this implies a rise in g if the selection curve is not too steep or the entry curve not too flat.

If also charged upon exit ($F_x = 1$), firing costs act as a tax on exit. Compared to the benchmark economy, they reduce both the expected value of continuing and the value of exit. The latter drops slightly more because it implies bearing firing costs immediately. Continuing implies bearing them only later, so they get discounted when entering the value of continuing.[8] Only the small difference between the changes to the value of continuing and the value of exit affects the exit threshold, reducing it slightly compared to the benchmark case. The lower threshold implies weaker selection and the survival of more low-productivity

---

[8] Bentolila and Bertola (1990) make a similar point in their analysis of firing costs and average employment.

firms, resulting in a lower g given $\hat{w}$, and thus a slight shift of the selection line down to the dotted line. Combined with the shift in the entry curve, both growth and $\hat{w}$ unambiguously fall.

To summarize, firing costs intensify selection and can raise growth when only charged to continuing firms, while they reduce both when also charged to exiting firms. Besides the effect on the growth rate, there is a double level effect. First, because of the adjustment cost, firms' employment will not always be optimal, reducing allocative efficiency exactly as in Hopenhayn and Rogerson (1993). Moreover, due to the lower wage, average firm size rises. With less and larger firms, the production structure is less efficient than in the benchmark economy because of decreasing returns. As a result, lifetime consumption is unambiguously lower in the case where firing costs are always due, whereas the relative size of changes in the growth rate and levels matters when exiting firms are exempt.

5.2 Quantitative evaluation

This section reports quantitative results on the effect of altering the benchmark economy by introducing firing costs of ψ times the equilibrium wage for each worker fired. ψ is set to one, i.e. a year's wages. This is close to the average over continental European countries according to the OECD's employment protection indicators.

5.2.1 Results for the benchmark economy

Results for the benchmark economy are reported in Table 3. Most salient are the changes in growth rates. Introducing firing costs decreases the growth rate by around 1 tenth of a percentage point when firing costs are always charged. When exiting firms are exempt, the growth rate rises by almost a tenth of a percentage point.[9] The difference in g between the

---

[9] This growth increase comes at the cost of the well-known distortion of employment by which firing costs reduce the level of aggregate productivity (Hopenhayn and Rogerson 1993). This explains the consumption and wage numbers in Table 3. In fact, by the following argument, the level effect dominates the growth effect, so that scrapping firing costs raises lifetime consumption. Neglecting the transition, the reduction in growth from scrapping firing costs has a cost corresponding to 1.5% of lifetime consumption. As the growth rate adjusts slowly, this is an upper bound on the cost. At the same time, firms instantly move to

two firing cost regimes thus amounts to almost 0.2 percentage points.

[Table 3 about here]

The changes in the strength of the selection process driving these changes in g are also reflected in changes in the survival rate of entrants. The size of the changes in the growth rate is large enough to be relevant but smaller than the sometimes very large effects of policy on growth rates found in other endogenous growth models.[10]

Besides growth, the most interesting result is the sharp fall in job turnover. The negative effect of firing costs on job turnover is empirically well-established (see e.g. Micco and Pagés 2006, Haltiwanger, Scarpetta and Schweiger 2008, Kugler and Pica 2008). What is interesting here is that the contribution of exiting firms to job turnover is small, so that the exit exemption barely affects it. As a consequence, exempting exiting firms from firing costs boosts growth quite a bit without affecting job turnover very much. This means that potential non-modeled costs of job turnover should not matter much for the comparison of the two regimes.

5.2.2 Sectoral and cross-country differences

Employment protection legislation constrains firms more strongly in sectors where idiosyncratic shocks have a large variance (see e.g. Micco and Pagés 2006, Cuñat and Melitz 2007). This should have implications for growth. And indeed, the most important growth difference between the U.S. and Europe (almost half a percentage point in the 1990s, Blanchard 2004, Table 4) was in services, a sector with more variable idiosyncratic shocks.[11]

How much of this does the model predict? Table 4 shows the effect of firing costs of a year's wages in an economy where σ^2, the variance of the idiosyncratic shock, is raised from

---

optimal employment. This reallocation effect alone raises consumption by 1.5%. More gains follow along the transition as more firms enter, resulting in a net gain.

[10] Changes in g are small because of firm heterogeneity. In many endogenous growth models, policy affects all firms, implying large growth effects. Here, in contrast, firing costs mainly affect the exit behavior of firms close to the exit threshold, leading to a smaller aggregate effect.

[11] The coefficient of variation of firm size in services is up to three times as high as in manufacturing (see BHS) and job and firm turnover are higher (Bartelsman et al. 2003, Davis, Faberman and Haltiwanger 2006).

0.113 to 0.14 to mimic the service sector. First note that this sector has a higher growth rate than the benchmark economy. This is the positive effect of σ^2 on the growth rate discussed in Section 3.3: Larger shocks imply both faster productivity growth of surviving firms and the replacement of more low-productivity firms by better entrants. Job turnover and productivity dispersion are also higher, as in the data.

[Table 4 about here]

In this setting, firing costs have a stronger effect for both settings of F_x. If they are only charged to continuing firms ($F_x = 0$), there is stricter selection, and the growth rate rises by almost 0.4%. If they are also charged to exiting firms ($F_x = 1$), g drops by 0.13% – around a quarter of the difference observed in the data. Thus, while firing costs reduce growth by an important but small amount in the benchmark economy, they have a stronger effect in the high-volatility sectors where growth rate differences were largest and explain part of the sectoral pattern of growth rate differences between the U.S. and Europe.[12]

5.3 Implications for policy and research

With regard to policy design, the results show that details of EPL regimes matter, and that dealing with exit efficiently should be a serious policy concern. The replacement of low-productivity firms is a powerful growth engine, as shown by Foster et al. (2001) and others and modeled here, and firing costs interfere with it. Importantly, charging firing costs to exiting firms does not reduce job turnover by much, but has potentially large costs in terms of growth compared to charging them only to continuing firms. This result is particularly relevant since even if EPL is well-entrenched and hard to reform, there may be more flexibility in the treatment of exiting firms, which differs substantially across countries.[13]

---

[12] An additional dimension also fits well. In the model, firing costs reduce job turnover by a similar proportion in the benchmark economy and in “services”. The ratio of job turnover in services to that in the overall economy thus does not vary with firing costs. This is consistent with the data; the ratio is very similar across countries in the data used by Haltiwanger et al. (2008) despite differences in firing costs.

[13] In many countries, laid-off workers may obtain claims on assets of the firm even if the firm is liquidated. The seniority of these claims varies widely across countries, cf. Johnson (2003), and determines whether any firing costs are due upon exit in the sense of the model.

The results also have implications for empirical work. Countries differ in their treatment of exiting firms. Because this matters for the sign of the theoretically predicted relationship, an empirical analysis must take it into account. Otherwise, estimates of the effect of firing costs on growth are likely to be weak or hard to interpret. [14]

6 Conclusion

This paper has analyzed the effect of firing costs on productivity growth, a topic that despite its evident importance has received much less attention than their impact on employment or on the level of productivity. To perform the analysis, a model of growth through selection and experimentation has been developed, taking into account recent evidence on firm dynamics, particularly on the importance of job turnover, firm heterogeneity, and the contribution of entry and exit to aggregate productivity growth. In the model, growth occurs endogenously due to selection among incumbents and due to imitation by entrants. In a nutshell, selection eliminates the worst active firms. Modeling mean productivity of entrants as a constant fraction of the productivity frontier, the model economy grows through rightward shifts of the firm productivity distribution. The more variable the fate of firms in the economy, the stronger the selection mechanism, and the faster growth.

In this setting, firing costs do not only induce a misallocation of labor, reduce firm value and discourage entry as in other models, but also discourage exit of low-productivity firms. This congests the selection process and slows down growth. Their effect is stronger the more variable firms' productivity is. Through this mechanism, the model matches the fact that in recent years, productivity growth differences between the EU and the U.S. were largest in the high-turbulence service sector. Modeling aggregate productivity growth in accordance with the evidence on firm dynamics and matching this fact is the first contribution of the

---

[14] For instance, Scarpetta et al. (2002) find that EPL reduces productivity growth and firm entry rates. The latter suggests that on average in their sample, EPL also applies to exiting firms (otherwise entry and exit rates should rise). Their results might be sharper had they accounted for the treatment of exiting firms. A previous version of this paper (available as IZA Discussion Paper 3164) provides some evidence that the treatment of exiting firms matters for exit behavior.

paper.

The second contribution lies in the analysis of the treatment of exiting firms. Exempting exiting firms from firing cost speeds up the exit of inefficient firms and thereby growth. Since job turnover is not much higher than without the exemption, it is likely that the cost to growth from charging firing costs to exiting firms exceeds any (here unmodeled) benefits of slightly reducing job turnover. The treatment of exiting firms is an important factor neglected by empirical work on EPL and growth, a fact that may explain weak results in that literature.

References

Alvarez, F., Veracierto, M., 2001. Severance Payments in an Economy with Frictions. Journal of Monetary Economics 47, 477–498.

Bartelsman, E.J., Doms, M., 2000. Understanding Productivity: Lessons from Longitudinal Microdata. Journal of Economic Literature 38(3), 569–594.

Bartelsman, E., Haltiwanger, J., Scarpetta, S., 2004. Microeconomic Evidence of Creative Destruction in Industrial and Developing Countries. World Bank Policy Research Working Paper 3464.

Bartelsman, E., Scarpetta, S., Schivardi, F., 2003. Comparative Analysis of Firm Demographics and Survival: Micro-Level Evidence for the OECD Countries. OECD Economics Department Working Paper 348.

Bentolila, S., Bertola, G., 1990. Firing costs and labor demand: how bad is eurosclerosis? Review of Economic Studies 57, 381–402.

Bertola, G., 1994. Flexibility, Investment, and Growth. Journal of Monetary Economics 34(2), 215–238.

Blanchard, O., 2004. The Economic Future of Europe. Journal of Economic Perspectives 18(4), 3–26.

Cuñat, A., Melitz, M., 2007. Volatility, Labour Market Flexibility, and the Pattern of Comparative Advantage. NBER Working Paper 13062.

Davis, S.J., Haltiwanger, J.C., Schuh, S., 1996. Job creation and destruction. MIT Press, Cambridge, Mass..

Davis, S.J., Faberman, R.J., Haltiwanger, J., 2006. The Flow Approach to Labor Markets: New Data Sources and Micro-Macro Links. Journal of Economic Perspectives 20(3), 3–26.

Dwyer, D.W., 1998. Technology Locks, Creative Destruction, and Nonconvergence in Productivity Levels. Review of Economic Dynamics 1(2), 430–473.

Foster, L., Haltiwanger, J., Krizan, C.J., 2001. Aggregate Productivity Growth: Lessons from Microeconomic Evidence. In: Hulten, C.R., Dean, E.R., Harper, M.J. (Eds.), New Developments in Productivity Analysis, NBER Studies in Income and Wealth. University of Chicago Press, Chicago.

Foster, L., Haltiwanger, J., Krizan, C.J., 2006. Market Selection, Reallocation, and Restructuring in the U.S. Retail Trade Sector in the 1990s. Review of Economics and Statistics 88(4), 748–758.

Franco, F., Philippon, T., 2007. Firms and Aggregate Dynamics. Review of Economics and Statistics 89(4), 587–600.

Gabler, A., Licandro, O., 2006. Endogenous Growth through Firm Entry, Exit and Imitation. European University Institute Mimeo.

Gust, C., Marquez, J., 2004. International comparisons of productivity growth: the role of information technology and regulatory practices. Labour Economics 11(1), 33–58.

Haltiwanger, J.C., 1997. Measuring and Analyzing Aggregate Fluctuations: The Importance of Building from Microeconomic Evidence. Federal Reserve Bank of St. Louis Review 3, 55–77.

Haltiwanger, J.C., Scarpetta, S., Schweiger, H., 2008. The Relationship Between Job Flows across Countries: The Role of Industry, Firm Size and Institutions. NBER Working Paper 13920.

Hopenhayn, H., Rogerson, R., 1993. Job Turnover and Policy Evaluation: A General Equilibrium Analysis. Journal of Political Economy 101(5), 915–938.

Johnson, G., 2003. Insolvency and Social Protection. World Bank Mimeo.

Jovanovic, B., 1982. Selection and the Evolution of Industry. Econometrica 50(3), 649–670.

Kugler, A., Pica, G., 2008. Effects of employment protection on worker and job flows: Evidence from the 1990 Italian reform. Labour Economics 15(1), 78–95.

Luttmer, E., 2007. Selection, Growth and the Size Distribution of Firms. Quarterly Journal of Economics 122(3), 1103–1144.

Micco, A., Pagés, C., 2006. Employment Protection and Gross Job Flows: Evidence from International Industry-Level Data. IZA Discussion Paper 2433.

Nicoletti, G., Scarpetta, S., Boylaud, O., 2000. Summary Indicators of Product Market Regulation with an Extension to Employment Protection Legislation. OECD Economics Department Working Paper 226.

Pierre, G., Scarpetta, S., 2004. Employment regulations through the eyes of employers: Do they matter and how do firms respond to them?. World Bank Research Paper 3463.

Rossi-Hansberg, E., Wright, M., 2007. Establishment Size Dynamics in the Aggregate Economy. American Economic Review 97(5), 1639–1666.

Saint-Paul, G., 2002. Employment protection, international specialization, and innovation. European Economic Review 46(2), 375–395.

Samaniego, R.M., 2006a. Do Firing Costs affect the Incidence of Firm Bankruptcy? Macroeconomic Dynamics 10(4), 467–501.

Samaniego, R.M., 2006b. Employment protection and high-tech aversion. Review of Economic Dynamics 9(2), 224–241.

Scarpetta, S., Hemmings, P., Tressel, T., Woo, J., 2002. The Role of Policy and Institutions for Productivity and Firm Dynamics: Evidence from Micro and Industry Data. OECD Working Paper 329.

Veracierto, M., 2001. Employment Flows, Capital Mobility, and Policy Analysis. International Economic Review 42(3), 571–595.

Table 1: Calibration: Model statistics, calibration targets (U.S., all data for 1990s)

Statistic	model	U.S.
Average employment at plant	26.4	26.4
Labor force participation	66%	66%
Relative productivity of entrants	99%	99%
Job turnover rate	26.6%	28%
Four-year survival rate of entrants	62.0%	63%
Share of aggregate productivity growth due to entry and exit	26.7%	26%
not used in calibration:		
Productivity dispersion	3.5	2 to 4
Seven-year growth rate of entrants	45.0%	40%
Output per capita growth	2.44%	

Sources for U.S. data: Bartelsman et al. (2003), Bartelsman et al. (2004), Bureau of Labor Statistics (http://data.bls.gov), Foster et al. (2001), Dwyer (1998). Relative productivity of entrants is computed as the productivity of entrants that entered within the last ten years relative to the average. The share of aggregate productivity growth due to entry and exit is computed as in Foster et al. (2001). Productivity dispersion is the ratio of the 85th to the 15th percentile of the productivity distribution.

Table 2: Calibration: Parameter values

Parameter	Value	Description
α	0.64	Labor share
β	0.95	Discount factor
θ	1.09	Disutility of working
σ_e^2	0.829	Variance of log productivity distribution of entrants
σ^2	0.113	Variance of idiosyncratic productivity shock
ϕ^f	1.3%	Fixed operating cost, % of avg firm output
ϕ^e	260%	Cost of entry, % of avg firm output
κ	2.1	Log prodty difference best incumbents/avg entrant

Table 3: Results: Introducing firing costs (always: $F_x = 1$, exit exemption: $F_x = 0$)

Statistic	Benchmark	$F_x = 0$	$F_x = 1$
Average employment at plant	26.4	31.9	26.5
Labor force participation	66.0%	65.7%	65.1%
Relative productivity of entrants	99.0%	100.6%	99.5%
Job turnover rate	26.6%	9.4%	9.0%
Four-year survival rate of entrants	62.0%	61.7%	62.4%
Productivity dispersion	3.5	3.3	3.4
Output per capita growth	2.44%	2.52%	2.35%
Consumption and wage (bm = 100)	100	92.5	96.6

Notes: $F_x = 1$: firing costs due upon all firings. $F_x = 0$: firing costs due upon firing only if firm does not exit. The last two columns report figures for an economy that is identical to the benchmark economy, except for the presence of firing costs of a year's wages.

Table 4: Results: Service sector (always: $F_x = 1$, exit exemption: $F_x = 0$)

Statistic	Benchmark	$F_x = 0$	$F_x = 1$
Average employment at plant	33.4	42.2	33.3
Labor force participation	67.1%	66.4%	65.3%
Relative productivity of entrants	98.3%	99.8%	98.5%
Job turnover rate	32.9%	12.5%	11.7%
Four-year survival rate of entrants	63.2%	62.4%	63.6%
Productivity dispersion	3.6	3.5	3.8
Output per capita growth	3.7%	4.1%	3.6%
Consumption (bm = 100)	100	90.7	96.1

Notes: $F_x = 1$: firing costs due upon all firings. $F_x = 0$: firing costs due upon firing only if firm does not exit. The “service sector” is an economy that is identical to the benchmark economy, except for a higher variance of the idiosyncratic shock. The last two columns report figures for an economy that is identical to the “service sector”, except for the presence of firing costs of a year’s wages.

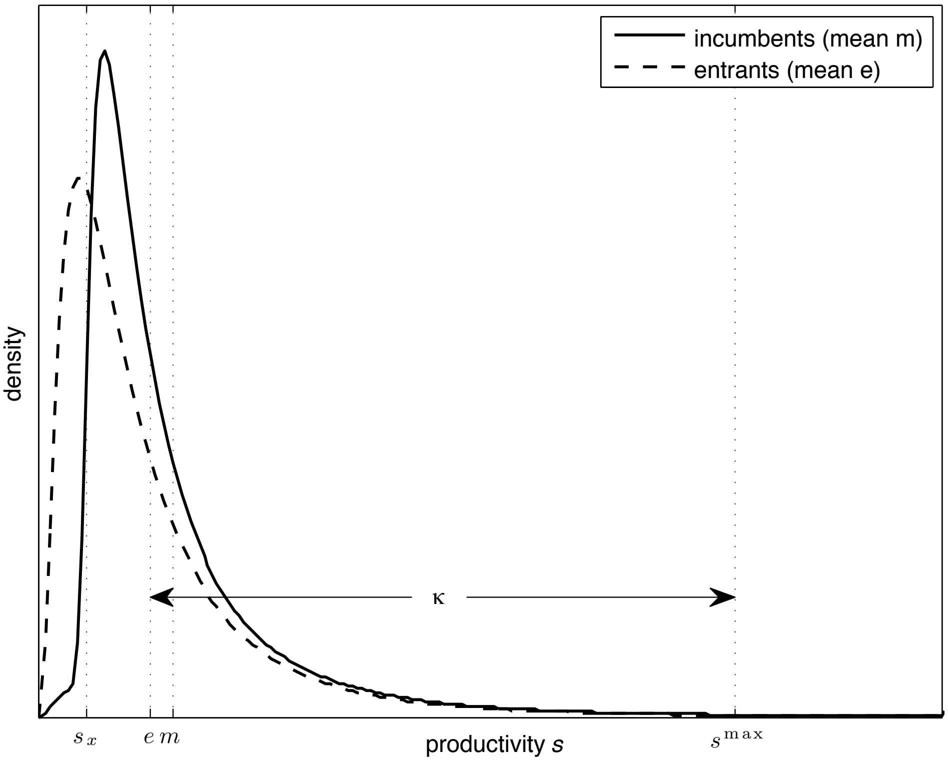

Figure 1: Productivity distribution of entrants (η) and incumbents (μ), log difference: κ

Note: The figure shows the distribution of incumbents (solid line) and entrants (dashed line) in the benchmark calibration of the model. s_x denotes the productivity exit threshold, $s^{\max}$ the productivity of the most productive firms, and κ the average log productivity difference between entrants and these top firms.

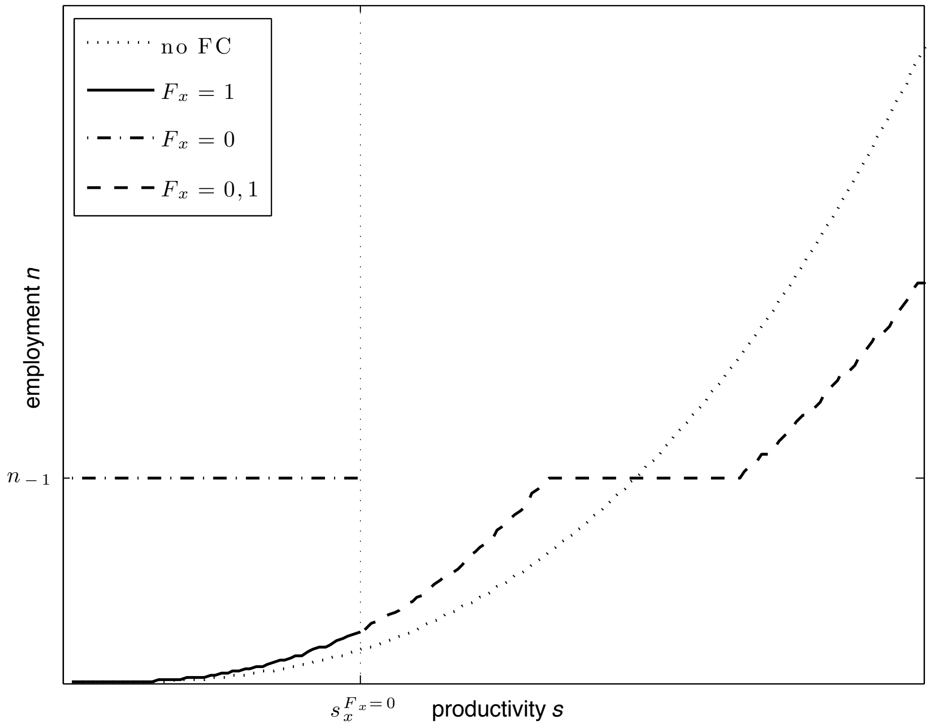

Figure 2: The employment policy function given past employment n_{-1}

Note: The figure shows a firm's labor demand as a function of current productivity s, given last period's employment n_{-1}. $F_x = 1$ refers to the setting where firing costs are always due, also for exiting firms. $F_x = 0$ refers to the case where only continuing firms pay firing costs. For s greater than s_x, the exit threshold in this latter case, the labor demand functions coincide.

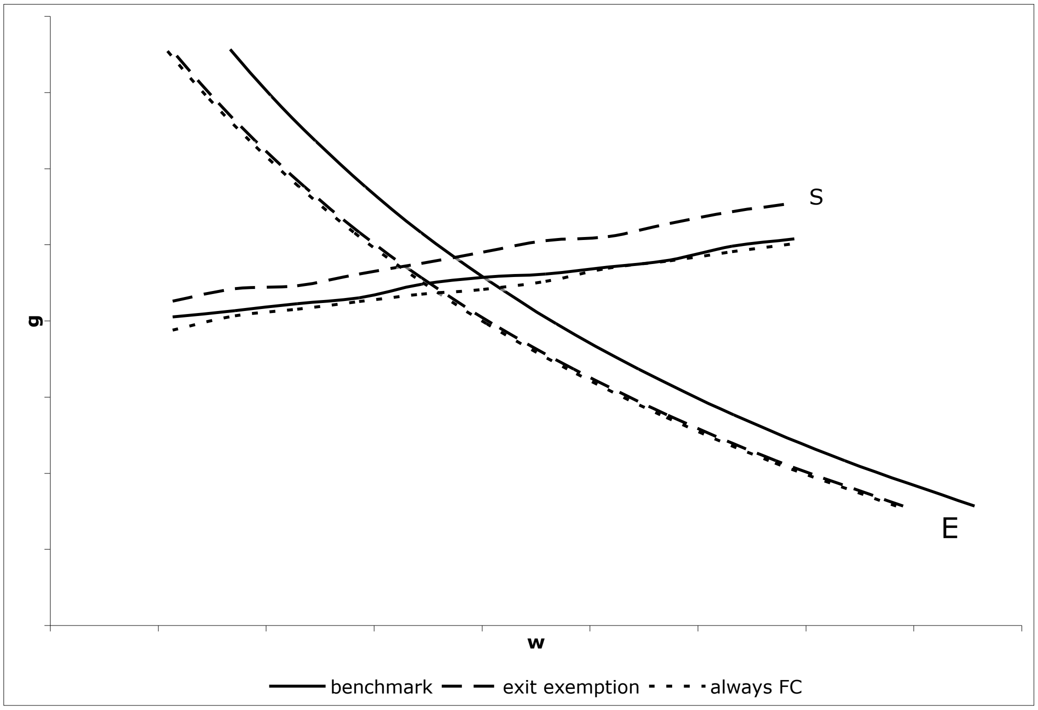

Figure 3: The free entry (E) and selection (S) conditions

Note: The free entry condition (E) holds for the combinations of g and $\hat{w}$ traced out by the solid line labeled E. Similarly, the line labeled S traces out the combinations for which the balanced growth condition (S) holds. The dashed and dotted lines represent these conditions when firing costs are introduced in the benchmark economy.