Job Flow Dynamics and Firing Restrictions

Pietro Garibaldi
(International Monetary Fund)
Washington D.C., 20431, U.S.A. email: pgaribaldi@imf.org *

First Version: December, 1994
This version: January, 1997
forthcoming in the *European Economic Review*

Abstract

This paper proposes and solves a stochastic search model with endogenous job separation and shows that the amplitude and time variation of job reallocation depend crucially upon the arrival rate of exogenous firing permissions. The tighter the firing restrictions, the less volatile is job destruction and the higher the correlation between job reallocation and net employment changes. Furthermore, as firing restrictions increase, the average level of job reallocation falls while equilibrium unemployment is approximately constant. A parameterization of the model can rationalize cross-country differences in the cyclical behaviour of job creation and destruction.

JEL nos. E24, J63.

Keywords: Matching models, Unemployment, Job Flows, Firing Costs.

*The first version of the paper was written when I was at the Centre for Economic Performance and it was circulated as CEP Discussion Paper num. 256. I am particularly indebted to Chris Pissarides and Giuseppe Bertola for suggestions at various stages of the project. I also benefited from the comments of Claudio Michelacci, Francois Bourguignon and two anonymous referees. I thank my Ph.D. examiners Alan Manning and Kenneth Burdett and the participants to the seminars at the VII ESWC in Tokyo, at the IX EEA meeting in Maastricht, at the London School of Economics, at Igier-Bocconi, at Università Cattolica del Sacro Cuore, at McMaster and at La Sorbonne University. The views expressed in the paper are those of the author and do not necessarily represent those of the *International Monetary Fund.* Address for correspondence: Pietro Garibaldi, International Monetary Fund, 20431, Washington D.C. e-mail:pgaribaldi@imf.org

1 Introduction

The measurement of job creation and job destruction for the U.S. manufacturing sector cast new light on labour market dynamics. Following Davis and Haltiwanger's seminal papers (1990; 1992), empirical studies on employment changes at the establishment level have been performed in most OECD countries (OECD, 1994a)[1]. Job destruction in the U.S. and Canada features wider fluctuations than job creation, and causes job reallocation – the sum of job creation and destruction– to move countercyclically. By contrast, no asymmetry between time variation in job creation and destruction is apparent in continental Europe.

Bentolila and Bertola (1990) and Bertola (1990) argue that high firing costs in Europe and differences in employment protection legislation between countries may explain differences in the dynamics of employment even though they do not necessarily explain low employment on average. This paper follows this line of research and argues that differences in employment protection legislation can theoretically be responsible for observed differences in the cyclical behaviour of job creation and destruction. Using a stochastic search model with endogenous job separation, we show that the amplitude and time variation of job reallocation depend crucially upon the arrival rate of exogenous firing permissions. Finally, a parameterization of the model helps rationalise cross-country differences in the cyclical behaviour of job creation and destruction.

We build on the recent matching framework developed by Mortensen and Pissarides (1994; 1993) and Mortensen (1994). Mortensen and Pissarides have extended the traditional matching approach (Pissarides 1985; 1990; and Mortensen 1991) by assuming an economy populated with a continuum of jobs that differ in the value of a firm's specific productivity. The idiosyncratic risk for existing jobs is modeled as a jump process characterized by a Poisson arrival frequency and a drawing from a common distribution of productivity. Negative shocks induce job destruction but the firm endogenously chooses the value of labour product to which correspond instantaneous job destruction. Job creation comes from the posting of costly vacancies that are slowly matched to unemployed job seekers. In Mortensen Pissarides (hereafter MP 1994), the asymmetry between hiring and firing technologies rationalises the observed asymmetry between time variation of job creation and job destruction in U.S. manufacturing flows (Davis and Haltiwanger, 1990). However, in its original form, the MP model cannot rationalise the cyclical behaviour of job flows in continental Europe.

[1]Examples of country studies are Contini et al. (1992) for Italy, Boeri and Cramer (1993) for Germany, Baldwin et al, (1994) for Canada, Konings (1995) and Blanchflower and Burgess (1994) for the U.K. OECD (1994a) has tried to standardize these findings as much as possible.

Our departure from the MP (1994) model is the modeling of employment protection legislation and job security provisions. Firing and job destruction are no longer instantaneous but can be costly and lengthy. The simplest and most widely modeled form of employment protection legislation is a *fixed firing cost* to be incurred by the firm when firing takes place (Bentolila and Bertola 1990 and Bentolila and Saint-Paul 1994 in partial equilibrium models of labour demand; Burda 1992; Millard 1994 and Millard and Mortensen 1994 in search-equilibrium models). We focus on a different form of job security provisions and consider an economy in which firing requires an exogenous *firing permission*. We show that the traditional fixed firing costs and the more complex firing permission have similar steady state effects, in the sense that they both reduce the job finding rate and have an ambiguous effect on unemployment. Conversely, the dynamic effects of different forms of employment protection legislation vary substantially. A simple fixed firing cost, as in Millard (1994), does not reduce the asymmetry between time variation in job creation and destruction. In the alternative formalization of this paper, tighter firing restrictions smooth out the increase in job destruction during recession and tend to make the dynamics of job destruction symmetric to the dynamics of job creation.

Finally, with respect to the MP (1994) model, where wages are the outcome of bilateral bargaining, we assume that wages are set by the firms at the workers reservation utility or that the firm continuously extracts all the surplus from the match. The rest of the assumptions are introduced in Section 3, and they are totally in line with the recent matching literature. Section 2 briefly looks at the existing empirical evidence on the cyclical behaviour of job flows and discusses the modeling of job security provisions and firing constraints. Section 3 presents and solves the steady state model. In Section 3 the aggregate conditions are fixed while they stochastically jump between "good" and "bad" times in Sections 4 and 5. Section 6 presents a parameterization of the model that helps to rationalise cross-country evidence on the cyclical behaviour of job flows.

2 The Empirical Evidence

2.1 The Cyclical Behaviour of Job Flows

Empirically, aggregate job creation (destruction) is defined as the sum of positive (negative) employment changes at the establishment level in a given time interval and in a specific country. If we divide the number of jobs created (destroyed) by total employment, we obtain the job creation (destruction) rate. The sum of job creation and destruction is called job reallocation and is a measure of employment reshuffle across establishments. Finally, the difference between job creation and destruction is the traditional measure of net employment change.

Davis and Haltiwanger compiled establishment data for the U.S. manufacturing sector (1990; 1992) and showed that job creation and job destruction are negatively but not perfectly correlated, indicating that significant job creation (destruction) persists during recessions (booms). If we take net employment changes as a measure of the cycle, job creation is pro-cyclical and job destruction is countercyclical. But in the United States the increase in job destruction during recessions appears much more pronounced than the increase in job creation during expansions. As a result, job reallocation moves countercyclically[2].

Following Davis and Haltiwanger's research, measurement of employment changes at the establishment level has been carried out in most OECD countries. Table 1 reports Spearman's correlations between job flows and net employment changes for nine countries. Similar to the U.S. experience, job creation is pro-cyclical, job destruction is countercyclical, and job creation is negatively correlated with job destruction. Remarkable differences exist in the amplitude of fluctuations of job creation and destruction. We focus on three simple statistics in Table 1 and Table 2. The first column of Table 2 reports the relative variance of job destruction and job creation and shows that the U.S. evidence, where the ratio is greater than two, is confirmed only in the U.K., and to a lesser extent in Canada and Norway. To differences in the relative variances of Table 2 correspond differences in the cyclical behaviour of job reallocation in Table 1. The U.S. evidence, that shows job reallocation fluctuating countercyclically, is replicated in the United Kingdom, where the correlation is negative and significant. In Canada, even if negative, the correlation is not significantly different than zero [3]. Table 2 reports also the coefficients of variation and shows that job creation and destruction appear, proportionally to their mean, more volatile in Anglo saxon countries than in Continental Europe, with the exception of Norway. Overall, there is a clear dichotomy in the cyclical behaviour of job flows. On one side we find the North-American and British experience, where job destruction is more volatile than job creation and job

[2] Since job reallocation (JR) is the difference between job creation (JC) and job destruction (JD), it follows that

$$COV(JR, NET) < 0 \rightarrow VAR(JD) > VAR(JC),$$

where NET is the difference between JC and JD.

[3] Boeri (1995), using data for 8 OECD economies, argues that job reallocation is countercyclical only in the U.S., but in his data set Britain is missing and data from Canada range from 1978 to 1988, whereas the most recent data compiled by Baldwin et al. (1994) range from 1973 to 1988.

reallocation moves countercyclically. On the other side we find the Continental Europe experience, where job reallocation tends to be acyclical and the fluctuations in job creation and destruction are less pronounced.

2.2 Employment Protection Legislation

Employment protection legislation is a form of employment regulation which relates to employers' freedom to dismiss workers. OECD (1994b) argues that employers' freedom to dismiss may be restricted in several ways: with requirements to give several month notice to the worker before dismissal becomes effective, and/or to provide severance payments upon dismissal; with requirements for prior warnings or written justification to the person to be dismissed or for authorisation from a third party before dismissal can take place; with requirements that rehabilitative measures be attempted before a worker is dismissed; with provisions for appeal against unfair dismissal.

The multiple dimensions of employment protection are difficult to model in an simple way. Most of the work in the area, notably Bentolila and Bertola (1990), collapses the multidimensional aspects of employment protection legislation into a simple fixed firing cost, to be incurred by the firm when separation takes place. This simplification has the advantage of being analytically simple and, at least conceptually, empirically observable (OECD 1994b; Grubb and Wells 1993).

In most European countries, before firing can take place a discussion with union representative is often necessary and, in extreme cases, a full agreement with government officials must be reached (Emerson, 1988). From the firm stand-point, the existence of complicated procedures introduce uncertainty over the actual costs of firing and the actual time of shedding. Firstly, European firms discuss with the union the amount of severance payments to be paid to the employees. Secondly, firms do not know exactly the moment in which the negotiations with the unions will end. Finally, the existence of a "just clause" rule in most European legislation allows the worker to appeal against dismissal and can result in reinstatement of the dismissed worker. The traditional indicators of firing costs may capture the uncertainty over total firing costs, but they definitely fail to capture the uncertainty over the actual timing of labour shedding.

The only indicator that tries to measure the restrictiveness of procedural obstacles to the implementation of no-fault dismissal is the index compiled by ILO, which classified regulatory constraints as insignificant, minor, serious or fundamental. Comparison of Tables 1, 2 and 3, which reports the ILO index for the same countries for which we have flows data, shows that countries that experience asymmetric behaviour in the dynamics of job creation and job destruction are countries with insignificant firing constraints. Conversely, continental Europe countries with symmetric behaviour in the dynamics of job creation and destruction have serious or fundamental firing constraints.

The easiest way to capture the effects of procedural constraints in an aggregate model is to assume that a firm can accomplish firing only when it is granted an *exogenous firing permission*. More formally, we assume that the arrival rate of firing permissions is a Poisson process with average waiting time equal to $1/s$. A job in good business conditions is an operational job, while a job in bad business conditions without firing permission is an *idle job*. An economy with no firing restrictions is an economy with an average waiting time of firing permissions equal to zero. On the other hand, the longer the waiting time (i.e. the lower the arrival rate s), the tighter the firing restrictions and the higher are the degrees of job security provisions. Results in Section 3.2 and Appendix (B) shows that exogenous firing restrictions, albeit with no immediate empirical counterpart, have very similar steady state properties to the simple fixed cost rule. With respect to job flow dynamics, Section 4 and Appendix (A) show that only firing permission dramatically affects the dynamic behaviour of the system. In this sense, the traditional fixed firing cost is not a good candidate for rationalising differences in the cyclical behaviour of job flows.

3 Concept and Notation

3.1 The model

We consider an economy populated by a continuum of risk-neutral workers of fixed quantity, normalised to one for simplicity. Workers can be in two states, employed or unemployed. Each firm has only one job which can be filled and producing or vacant. A filled job can be either fully operational or idle, depending on whether the firm is actually waiting for firing permissions. Following the empirical literature we define job creation as the moment in which a vacant job meets an unemployed worker. Similarly, job destruction takes place when an idle job gets a firing permission, separates and leaves the market.

As in MP (1994), each job is characterized by a fixed irreversible technology and produces at the productivity level $p + \sigma\epsilon$. The productivity is made up of an aggregate component p, common to every job and a job specific component ϵ[4]. The stochastic process regulating

[4] In the paper σ is simply a normalising parameter useful for the simulations of Section 6; it is common to every job and it will not play any specific role.

the idiosyncratic component of the productivity ϵ is Poisson with arrival rate equal to λ. In the event of a change in ϵ, the new value of the job specific productivity is a drawing from a fixed distribution $F(\epsilon)$, with finite upper support ϵ_u, lower support ϵ_l and no point mass, other than at the upper support ϵ_u. This way of modeling implies a memoryless but persistent idiosyncratic productivity. The persistence of any given productivity ϵ is $1/\lambda$.

We follow the earlier literature by assuming that new firms have the option to select the best productivity in the market, and create jobs at the upper support $p + \sigma\epsilon_u$. Following an idiosyncratic shock, however, the firm has no choice over its productivity. Filled job are said to be fully operative if the idiosyncratic productivity is above some critical value ϵ_d, while they are said to be idle if the job specific productivity is below ϵ_d. Operational jobs turn idle at rate $\lambda F(\epsilon_d)$ while idle jobs get firing permissions and leave the market at rate s. Finally, idle jobs are subject to idiosyncratic uncertainty and can return fully operational at rate $\lambda(1 - F(\epsilon_d))$.

Vacant firms and unemployed workers meet at rate $m(u, v)$, where m is a first-degree homogeneous matching function and u and v are the number of vacancies and the number of unemployed normalised by the labour force. Vacancies are filled at the rate

$$q(\theta) = \frac{m(u, v)}{v}; \quad \theta \equiv \frac{v}{u}, \; \frac{\partial q(\theta)}{\partial \theta} < 0,$$

where θ is a measure of market tightness from the firm's point of view. Similarly, workers find job at rate

$$\theta q(\theta) = \frac{m(u, v)}{u}; \; \frac{\partial \theta q(\theta)}{\partial \theta} > 0.$$

Apart from the firing constraints, we depart from the standard MP (1994) framework in the wage-setting behaviour. Throughout the paper we assume that employers capture all the rents associated with a job-worker match by paying workers the common alternative value of their time, b. As Diamond (1971) has shown, this outcome is an equilibrium in a wage setting game played among employers when workers have only the power to accept or reject offers and workers search sequentially at some positive costs. Given this outcome, workers have no incentive to search on the job and their parameters, other than b, do not affect the equilibrium. Alternatively, if we allowed a continuously renegotiated Nash bargain between the firm and the worker, the wage would certainly be higher than the worker reservation utility in operational jobs, where the surplus from the match is positive. But the presence of firing restrictions would force the firm to pay the worker even when the job is idle and the worker's participation constraint is binding. This would force idle firms to offer the worker his reservation utility b, exactly as in the present model. Thus, a continuously renegotiated bargain would only affect the wage of operational jobs, leaving unchanged the behaviour of idle jobs, the distinctive feature of this model. To keep track of such bargains would be analytically tedious and would not change the qualitative results of the paper.

3.2 The Steady State

The present Section solves the model in steady state with fixed aggregate conditions, whereas in Section 4 the economy moves stochastically between relatively good and bad periods. In steady state, the asset valuation of a filled job, conditional on an idiosyncratic productivity ϵ is

$$rJ(\epsilon) = p + \sigma\epsilon - b + \lambda\left[\int_{\epsilon_l}^{\epsilon_u} J(x)dF(x) - J(\epsilon)\right] + s\left[\max(0, J(\epsilon)) - J(\epsilon)\right], \tag{1}$$

where $J(.)$ is the value of a job, r is the exogenous interest rate, $p + \sigma\epsilon - b$ are operational profits at idiosyncratic productivity ϵ. Apart from the flow-term $p + \sigma\epsilon - b$, (1) involves two capital gain terms. At rate λ the firm loses its current asset value $J(\epsilon)$ and draws a new ϵ from the productivity distribution. At rate s firing permissions arrive and the firm gets an option to destroy the job. Since a destroyed job has zero value, the max operator in (1) captures the idea that a firm will keep running a job as long as its value is positive. It follows that an operational job is a positively valued job that ignores firing permissions while an idle job is a negatively valued job that is destroyed when permissions arrive. Differentiating (1) with respect to ϵ it shows that $J(.)$ is a piece-wise increasing function of ϵ and its derivative reads

$$J\prime(\epsilon) = \frac{\sigma}{r + \lambda}\ \forall\epsilon : J(\epsilon) \geq 0, \tag{2}$$

and

$$J\prime(\epsilon) = \frac{\sigma}{r + \lambda + s}\ \forall\epsilon : J(\epsilon) < 0. \tag{3}$$

If we define the reservation productivity ϵ_d as

$$J(\epsilon_d) \equiv 0,$$

making use of (2) and (3), after an integration by parts, the expected value of a job in (1) reads

$$\int_{\epsilon_l}^{\epsilon_u} J(x)dF(x) = \frac{\sigma}{r + \lambda}\int_{\epsilon_d}^{\epsilon_u}(1 - F(z))dz - \frac{\sigma}{r + \lambda + s}\int_{\epsilon_l}^{\epsilon_d} F(z)dz. \tag{4}$$

The last term of (4) is the (negative) value of an idle job and is a measure of expected firing costs. As the average waiting time goes to zero ($s \to \infty$), the second term on the right hand side of (4) vanishes, firing is always possible and it is accomplished as soon as the value of the job is negative. To obtain the cut off value ϵ_d, below which the firm will accept firing permission, we make use of (4) and we evaluate (1) at $J(.) = 0$. The reservation productivity solves

$$p + \sigma\epsilon_d - b = -\frac{\lambda\sigma}{r+\lambda}\int_{\epsilon_d}^{\epsilon_u}(1 - F(z))\,dz + \frac{\lambda\sigma}{r+\lambda+s}\int_{\epsilon_l}^{\epsilon_d} F(z)dz. \tag{5}$$

Equation (5) is one of the key equations of the model and uniquely determines the reservation productivity as a function of the parameters r,λ,p,s,b,σ and the productivity distribution $F(\epsilon)$. The left hand side of (5) is the profit from the marginal operational job. In an economy with no firing constraints ($s \to \infty$), the second term on the right hand side vanishes, the marginal profit is negative and there is *voluntary labour hoarding* in equilibrium. When firing is instantaneous ($s \to \infty$) but hiring is costly, the firm will hoard labour up to the level in which current losses compensate savings of hiring costs if conditions improve. The presence of firing delays increases, through the last term in (5), the value of the marginal profits. As the average waiting time for firing permissions increase, a job will be kept running in bad times for a longer period of time because of exogenous constraints and there will be *institutional labour hoarding.* Since the firm anticipates firing restrictions when conditions are bad, in (5) the firm reduces the extent of voluntary labour hoarding. As s falls it is possible that firing restrictions become so high that the firm will accept firing permissions at a positive profit per period.

Differentiating (5) with respect to s,

$$\sigma\frac{\partial\epsilon_d}{\partial s} = \frac{\lambda\sigma}{r+\lambda}(1 - F(\epsilon_d))\frac{\partial\epsilon_d}{\partial s} + \frac{\lambda\sigma}{r+\lambda+s}F(\epsilon_d)\frac{\partial\epsilon_d}{\partial s} - \frac{\lambda\sigma}{(r+\lambda+s)^2}\int_{\epsilon_l}^{\epsilon_d} F(z)dz \tag{6}$$

and rearranging, yields

$$\frac{\partial\epsilon_d}{\partial s}\frac{s(r+\lambda F(\epsilon_d)) + r(r+\lambda)}{(r+\lambda)(r+\lambda+s)} = -\frac{\lambda}{(r+\lambda+s)^2}\int_{\epsilon_l}^{\epsilon_d} F(z)dz. \tag{7}$$

Thus $\frac{\partial\epsilon_d}{\partial s} \leq 0$: an increase in the average waiting time of permission (fall in s) increases the productivity at which the firm takes advantage of firing permissions. This is consistent with the firm anticipating long waiting time when conditions worsen.

The reservation productivity falls with p, the common productivity. Differentiating (5) with respect to $(p - b)$ yields

$$1 + \sigma\frac{\partial\epsilon_d}{\partial(p-b)} = \frac{\lambda\sigma}{r+\lambda}(1 - F(\epsilon_d))\frac{\partial\epsilon_d}{\partial(p-b)} + \frac{\lambda\sigma}{r+\lambda+s}F(\epsilon_d)\frac{\partial\epsilon_d}{\partial(p-b)} \tag{8}$$

and rearranging, yields

$$\sigma\frac{\partial\epsilon_d}{\partial(p-b)}\frac{(r+\lambda)r + s(r+\lambda F(\epsilon_d))}{(r+\lambda)(r+\lambda+s)} = -1. \tag{9}$$

Thus $\frac{\partial \epsilon_d}{\partial p} \leq 0$: as the productivity increases the firm will find it profitable to keep a job operational for a higher range of productivities. The effect of other parameters on the reservation productivity is ambiguous. Higher discount rate r reduces the flow of income from the job and makes labour hoarding less profitable. This would reduce ϵ_d. But simultaneously, the higher discount rate reduces expected firing costs and makes autonomous labour hoarding profitable. Similar arguments hold for changes in the arrival rate of idiosyncratic shocks. Higher λ corresponds to an increase in the arrival rate of productivity shocks. On the one hand the reservation productivity tends to decrease since the firm expects the duration of adverse conditions to be shorter. At the same time the probability of facing a firing procedure is higher and the net effect depends mainly on the distribution $F(.)$.

Job creation comes through the posting of vacancies. When creating a job we assume the existing technology is fully flexible and the productivity distribution is common knowledge. This implies that new firms have the option to select the best productivity in the market and job creation takes place at the upper support of the distribution (ϵ_u). A posted vacancy yields an asset return of $-c$ per period, c being the constant cost of hiring, and a probability $q(\theta)$ of being filled with a job created at the upper support of the distribution. The vacancy asset valuation is

$$rV = -c + q(\theta)\left[J(\epsilon_u) - V\right]. \tag{10}$$

With free entry into the job market there are, in equilibrium, zero expected profits ($V = 0$) (Pissarides 1990) and the value of a job equals the expected searching costs:

$$J(\epsilon_u) = \frac{c}{q(\theta)}, \tag{11}$$

where the value of a job at the upper support of the distribution is obtained subtracting (5) from (1) and reads

$$J(\epsilon_u) = \frac{(\epsilon_u - \epsilon_d)}{r + \lambda}. \tag{12}$$

(11) is the job creation condition and uniquely determines the vacancy unemployment ratio θ as a function of the parameters r,λ,c, the matching function $q(.)$, the upper support of the distribution ϵ_u and the reservation productivity ϵ_d[5].

Differentiating (11) with respect to common productivity p, yields

$$-\frac{\partial \epsilon_d}{\partial p}\frac{1}{r + \lambda} = -\frac{q'(\theta)c}{q(\theta)^2}\frac{\partial \theta}{\partial p}, \tag{13}$$

[5]It can easily be checked that if $c = 0$, $J(\epsilon_u) = 0$ from (11) and $\epsilon_d = \epsilon_u$.

and, making use of the facts that $\frac{\partial \epsilon_d}{\partial p} < 0$ and $q'(.) < 0$, $\frac{\partial \theta}{\partial p} > 0$. Higher common productivity, increasing the flow of future profits, increases job creation at given unemployment. Conversely, higher job security provisions reduce the expected value of a job and reduce the profitability of new jobs. Job creation at given unemployment falls. Differentiating (11) with respect to s,

$$-\frac{\partial \epsilon_d}{\partial s}\frac{1}{(r+\lambda)} = -\frac{cq'(\theta)}{q(\theta)^2}\frac{\partial \theta}{\partial s}, \tag{14}$$

making use of $\frac{\partial \epsilon_d}{\partial s} < 0$ (14) implies that $\frac{\partial \theta}{\partial s} > 0$.

To close the model we need to introduce unemployment. With a fixed labour force, a worker can be either unemployed or employed. If employed, a worker can be attached to a fully operational ($\epsilon \geq \epsilon_d$) or to an idle job $\epsilon < \epsilon_d$. Normalizing variables in terms of a constant labour force, the relationship among different labour force status is

$$u + n_j + n_i = 1, \tag{15}$$

where u is the unemployment rate, n_i is the employed idle capacity and n_j is the employed operational rate. Let us consider unemployment. In an interval dt, the outflow rate corresponds to the number of matches per unemployed times the number of unemployed; while the inflow rate corresponds to the fraction of workers in the idle state whose employers obtained firing permission. Unemployment dynamics reads

$$\dot{u} = sn_i(t) - \theta q(\theta)u(t), \tag{16}$$

where $\theta q(\theta)$ is the job finding rate. If job creation (job destruction) is defined as the sum of all positive (negative) employment changes, as in the empirical literature, (16) defines unemployment variation as the difference between job destruction and job creation. Simultaneously there are a number of fully operational jobs that are hit by a shock below the reservation productivity and enter the idle state. The outflow from the idle state corresponds to the idle jobs that have obtained firing permissions plus those idle jobs that, hit by a positive productivity shock, return to be fully operational. The inflow into the idle state is given by the operational jobs hit by a shock below the reservation productivity. The change in the idle rate is

$$\dot{n}_i = \lambda F(\epsilon_d)n_j(t) - [s + \lambda(1 - F(\epsilon_d))]\, n_i(t). \tag{17}$$

In steady state equilibrium, the unemployment rate and the employment composition between idle and operational jobs is constant. From (16) and (17) it follows that unemployment and the idle rate are constant if the inflow rate is equal to the outflow rate. Steady state idle rate is

$$n_i^* = \frac{\theta q(\theta)}{s} u^*. \tag{18}$$

Making use of (18), equilibrium unemployment is

$$u^* = \frac{\lambda F(\epsilon_d)}{\lambda F(\epsilon_d) + \frac{s+\lambda}{s}\theta q(\theta)}. \tag{19}$$

The steady state system is recursive and it reduces down to four equations. (5) uniquely determines the reservation productivity ϵ_d while (11), given ϵ_d, uniquely determines the vacancy unemployment ratio θ. Given θ and ϵ_d, (18) and (19) simultaneously determine unemployment and the idle rate. Finally, given the unemployment rate, θ determines vacancies[6].

If firing is unrestricted ($s \to \infty$), the idle rate in (18) tends to zero and equilibrium unemployment in (19) coincides with equilibrium unemployment in more standard matching models (MP 1994; Pissarides 1990). As the average waiting time increases, firing restrictions affect both job creation and job destruction decision (i.e. ϵ_d and θ) and they have an ambiguous impact on unemployment. Differentiating (19) with respect to s, it is obvious that the overall result depends on the particular values of the parameters and on the form of the productivity distribution.

Lower firing restrictions increase the job finding rate, $\theta q(\theta)$, through their positive effect on market tightness ($\frac{\partial\theta}{\partial s} > 0$). Steady state job reallocation is $2sn^* = 2\theta q(\theta)u^*$ and it depends on firing costs in a direct and indirect way. Stricter job security provisions lower the job hiring rate and negatively affect job reallocation. Simultaneously, higher firing costs indirectly affect job reallocation through their ambiguous effect on unemployment and the overall results depend upon parameters of the model. On the other hand higher common productivity reduces both unemployment and the idle rate[7].

The distinctive prediction of the model is that higher firing delays (lower s) reduce the job finding rate; the effect on job reallocation is likely to be negative, but overall ambiguous.

[6]The system (18) and (19) is fully stable and the convergence to the steady state equilibrium is monotonic. From the characteristic equation of the homogeneous system (18) and (19),

$$r^2 + r(s + \lambda + \theta q(\theta)) + \theta q(\theta)(s + \lambda) + s\lambda F(\epsilon_d) = 0, \tag{20}$$

it follows that both roots have negative real parts and the system is stable. Furthermore the convergence is monotonic since in (20)

$$\Delta = (s - \lambda - \theta q(\theta))^2 + 4s\lambda(1 - F(\epsilon_d)) \geq 0. \tag{21}$$

[7]Empirically, especially in the long-run, unemployment and productivity growth are not correlated. In the spirit of the model and in the rest of the paper p is a cyclical variable. Section 6 shows that when we let p be a cyclical variable its fluctuations results in countercyclical movements of unemployment.

In Appendix (B) we show that, as long as we look across steady-state equilibria, the comparative static of modeling firing delays are qualitatively similar to the comparative static of traditional fixed firing cost rules, as in Millard and Mortensen (1994); the only difference being that stricter firing restrictions have ambiguous effect on the job reallocation rate while the latter in the Mortensen Millard (1994) paper is unambiguously reduced by higher firing tax. Even though the prediction that higher firing costs reduce both job creation and destruction is common to many search models, empirical evidence is controversial (Bertola and Rogerson, 1996) [8]. In Garibaldi (1996) and Garibaldi et al. (1997) there is some evidence of a negative relationship between job reallocation and long-term unemployment. Countries with high long-term unemployment tend to have lower job reallocation and, as long as we exclude the role of firms' entry and exit, higher job security provisions. Nevertheless, the main interest of this paper concerns the effect of firing restrictions on the cyclical behaviour of job creation and destruction. From the next Section we turn explicitly to dynamics.

4 Job Flows and Cyclical Shocks

To study the cyclical behaviour of the model proposed in Section 3.2 we need an explicit driving force. In this paper we assume that job dynamics is driven by a single aggregate disturbance and we let the state of the economy be described by a realization of a first order Markov process. Aggregate conditions move stochastically between n states, indexed by net common productivity $x_z = (p - b)_z$ with $x_z > x_{z+1}$. Aggregate shocks are described by the elements π_{zj} of a nxn stochastic matrix that contains the probabilities that the aggregate productivity jumps from state z to state j. From the analysis in the previous Section it is clear that for each aggregate productivity the system is characterized by the pair $\{\epsilon_{dz}, \theta_z\}$. In this Section we describe the methodology for solving for pairs $\{\epsilon_{dz}, \theta_z\}$, $z = 1 \cdots n$. The techniques applied in this Section were first introduced by Mortensen (1994), but they have to be slightly modified to solve the model of this paper. In what follows, the two steps procedure for obtaining the reservation productivities is very similar to Mortensen (1994), apart for the presence of firing restrictions s, while the methodology for obtaining the market tightness is specific to the model of this paper.

The comparative static results of the previous Section let us infer that, in general, since $x_z > x_{z+1}$, $\epsilon_{dz} \leq \epsilon_{dz+1}$ and $\theta_{z+1} > \theta_z$. Since we assume that cyclical shocks are anticipated,

[8] Bertola and Rogerson (1996) argue that the fact that countries with different degrees of job security provisions have similar rates of job reallocation should not be surprising once we realize that countries with high job security provisions have also centralized wage-setting institutions.

we need to set out an aggregate state contingent value function for each job ϵ. The value of a job, conditional on aggregate state productivity x_z and idiosyncratic productivity ϵ now reads

$$\begin{aligned} rJ_z(\epsilon) &= x_z + \sigma\epsilon + \lambda\left[\int_{\epsilon_l}^{\epsilon_u} J_z(\tau)dF(\tau) - J_z(\epsilon)\right] + \sum_{j\neq z}\pi_{zj}\left[J_j(\epsilon) - J_z(\epsilon)\right] \\ &+ s\left[\max(J_z(\epsilon),0) - J_z(\epsilon)\right] \quad z,j = 1,\ldots,n, \end{aligned} \tag{22}$$

where at rate λ a job specific shock arrives, at rate π_{zj} an aggregate state switch occurs, while at rate s the firm gets firing permission. (22) can easily be written as

$$\begin{aligned} (r+\lambda+\sum_{j\neq z}\pi_{zj}+s)J_z(\epsilon) &= x_z + \sigma\epsilon + \lambda\int_{\epsilon_l}^{\epsilon_u} J_z(\tau)dF(\tau) + \sum_{j\neq z}\pi_{zj}J_j(\epsilon) \\ &+ s\left[\max(J_z(\epsilon),0)\right] \quad z,j = 1,\ldots,n. \end{aligned} \tag{23}$$

After dividing both terms by $(r+\lambda+\sum_{z\neq j}\pi_{zj}+s)$, the right hand side of (23) is a mapping that satisfies Blackwell's sufficient conditions for a contraction. The system in (23) has to be solved for the vector of reservation productivities. Each ϵ_{dz}, if it exists, is defined as $J(\epsilon_{dz}) = 0$, and we let R_d be a column vector containing the n reservation productivities. Differentiation of (23) with respect to ϵ shows that each value function $J_z(\epsilon)$ is a piece-wise linear increasing function in ϵ, with n kinks at values corresponding to elements of the vector R_d. The n consecutive kink points at $\epsilon_{dz} < \epsilon_{dz+1}$, together with $\epsilon_{lo} < \epsilon_1$ and $\epsilon_n < \epsilon_u$, divide the productivity distribution into $n+1$ interval of the form $[\epsilon_k - \epsilon_{k+1})$, with $\epsilon_0 = \epsilon_{lo}$ and $\epsilon_{n+1} = \epsilon_u$. In the first stage of the solution the derivative of each $J_z(\epsilon)$ for values of ϵ in the interval $[\epsilon_k - \epsilon_{k+1})$, is obtained as a solution to the linear system

$$(r+\lambda+\sum_{j\neq z}\pi_{zj}+\Phi s)\frac{\partial J_z}{\partial\epsilon} = \sigma + \sum_{j\neq z}\pi_{zj}\frac{\partial J_z}{\partial\epsilon} \quad z,j = 1,\ldots,n;\ \ \epsilon_k \leq \epsilon < \epsilon_{k+1}, \tag{24}$$

where Φ is an indicator function taking the value 1 if $\epsilon_{dz} > \epsilon_{k+1}$ and zero otherwise. Let D be an $(n, n+1)$ matrix whose general element d_{zk} gives the partial derivative of $J_z(\epsilon)$ in the interval $[\epsilon_k, \epsilon_{k+1})$. The elements of R_d are then obtained in the second stage as a solution to the following non linear system in the n reservation productivities:

$$x_z + \sigma\epsilon_{dz} = -\lambda E[J_z(\epsilon_1,\ldots,\epsilon_n)] - \sum_{j\neq z}\pi_{zj}J_j(\epsilon_{dz}) \quad z = 1,\ldots,n. \tag{25}$$

In (25) $E(J_z)$ is obtained integrating by parts (23) for each J_z using the partial derivatives d_{zj} obtained in the first stage. $E(J_z)$ is defined as

$$E(J_z) = \sum_{p=z}^{n} d_{z,p+1} \int_{\epsilon_p}^{\epsilon_{p+1}} (1 - F(\tau))\, d\tau - \sum_{p=0}^{z-1} d_{z,p+1} \int_{\epsilon_p}^{\epsilon_{p+1}} F(\tau) d\tau \tag{26}$$

Job creation takes place at the upper support of the productivity distribution. Depending upon the state of the system x_z, vacancies will be created so as to eliminate all possible rents. For each state z of the economy, an expression similar to (11) of Section 3.2 holds:

$$J_z(\epsilon_u) = \frac{c}{q(\theta_z)} \quad z = 1, \ldots, n. \tag{27}$$

To obtain the market tightness θ_z from (27) it is necessary to obtain an expression for the value of the job at the upper support of the distribution $J_z(\epsilon_u)$. Each $J_z(\epsilon_u)$, using the vector R_d obtained from (25) is one of the solutions to the following linear system:

$$(r + \lambda + \sum_{k \neq z} \pi_{zk}) J_z(\epsilon_u) = \sigma(\epsilon_u - \epsilon_{dz}) + \sum_{k \neq z} \pi_{zk} \left(J_k(\epsilon_u) - J_k(\epsilon_{dz}) \right) \tag{28}$$

and

$$\begin{aligned} (\quad r \quad & + \lambda + \sum_{k \neq j} \pi_{kj}) J_j(\epsilon_u) - (r + \lambda + \sum_{k \neq j} \pi_{kj} + \phi_2 s) J_j(\epsilon_{dz}) = \sigma(\epsilon_u - \epsilon_{dz}) \\ + & \sum_{k \neq j,z} \pi_{kj} (J_k(\epsilon_u) - J_k(\epsilon_{dz})) + \pi_{jz} J_z(\epsilon_u) \quad \text{for } j \neq z. \end{aligned} \tag{29}$$

In (29) ϕ_2 is an indicator function taking the value of 1 if $\epsilon_{dj} > \epsilon_{dz}$. The system (29) and (28) has to be solved recursively for each z, starting from $z = n$. In (28) and (29) the unknowns are $J_z(\epsilon_u)$, $(J_k(\epsilon_u) - J_k(\epsilon_{dz}))$ for $k < z$ and $J_k(\epsilon_{dz})$ for $k > z$, while $J_k(\epsilon_u)$, for $k > z$, enters the system as a parameter. Each $J_z(\epsilon_u)$ can then be substituted into (27) to obtain the corresponding θ_z. Since $x_z > x_{z+1}$ it will, in general, be true that $J_z(\epsilon_u) > J_{z+1}(\epsilon_u)$ and, from (27), $\theta_z > \theta_{z+1}$.

Appendix (A) shows how the introduction of firing restrictions affects the marginal productivity in a world in which the aggregate productivity can take only a high value p^* and a low value p. While we refer to Appendix (A) for the analytical details, the intuition of the results goes along the following lines. Obviously, if the state of the economy switches from recession to boom the marginal firm enjoys a pure capital gain, the value of its job turns positive and the firm will ignore firing permissions. Conversely, in the presence of an aggregate switch from boom to recession, a marginal job in boom has suddenly negative value and can be destroyed only when the firm gets firing permission. This last effect is what makes the dynamics of job destruction in this model different from the dynamic implied by a simple fixed firing cost to be incurred when job destruction takes place, along the line of Millard (1994). Appendix (C) shows that with a simple fixed firing cost, a marginal job in a boom will immediately be destroyed when the economy switches from boom to recession, exactly as in the original MP (1994) model. Conversely, in the model of this paper *job destruction not only is costly, but is also time consuming.* The simulations in Section 6 show that, depending on the value of s, the dynamic of job destruction may well be symmetric to the dynamic behaviour of job creation.

In structural terms, the hiring and firing technologies are governed by the parameters s, c, $p + \sigma\epsilon_d - b$ and by the matching function q. On the one hand the flow cost c in the hiring technology plays a role similar to the operational profits $p + \sigma\epsilon_d - b$ (generally negative) in the firing technology. As new vacancies have to pay the flow cost c, so an idle job must suffer operational losses when it waits for the firing permission. On the other hand, the average waiting time $1/s$ plays a similar role to the matching function q, in the sense that they both act as a stochastic filter and introduce a time lag between the moment in which the firms takes a decision (to post a vacancy or to accept firing permissions) and the moment in which a job-worker pair matches or separates.

5 Job Flow Determination

Both ϵ_z and θ_z are forward-looking jumping variables, independent of history. In general, as the aggregate state switches from x_z to x_j, both ϵ_z and θ_z will jump, on the impact, to their new values ϵ_j and θ_j. On the contrary, employment is a sticky variable and to implement the model we need to specify its dynamic behaviour at discrete time $t = 1, \ldots, n$. For this purpose it is necessary to keep track of the entire distribution of employment at each reservation productivity . If N_t is a measure of employment at time t, then $N_t = I_t + O_t$, where I_t indicates the idle jobs waiting for firing permission and O_t are the operational jobs that will ignore the arrival of firing permission. Following Mortensen (1994), we assume that the aggregate shock is completely revealed at the beginning of each period. In the time interval between t and $t+1$, $\epsilon_d(x_t)$ and $\theta_t(x_t)$ are state variables determined at the beginning of time t and constant throughout. If $O_t(\epsilon)$ is a measure of operational jobs at productivity ϵ its law of motion is

$$O_{t+1}(\epsilon) = (1-\lambda)O_t(\epsilon) + \lambda F'(\epsilon)(I_t + O_t), \ \ \epsilon_d(x_t) < \epsilon < \epsilon_u, \tag{30}$$

while the law of motion of idle jobs $I_t(\epsilon)$ is

$$I_{t+1}(\epsilon) = (1-\lambda)I_t(\epsilon) + \lambda F'(\epsilon)(I_t + O_t) - sI_t(\epsilon), \quad \epsilon_l(x_t) \leq \epsilon \leq \epsilon_d(x_t) \tag{31}$$

where the difference between (30) and (31) is that an idle job is destroyed if firing permission arrives. From the laws of motion (30) and (31) we can calculate job flows between t and $t+1$. The empirical definition of job creation is the sum of all positive employment changes in a given period. Since, in the model, only the unemployed people are actively searching, job creation between t and $t+1$ is

$$JC_t = q(\theta_t)\theta_t(1 - N_t). \tag{32}$$

If the matching function is log-linear with matching elasticity of unemployment α, $q(\theta_t)\theta_t$ from the job creation condition (27) is

$$q(\theta_t)\theta_t = kJ_t(\epsilon_u)^{\frac{1-\alpha}{\alpha}}, \tag{33}$$

where k is a scale parameter and $J_t(\epsilon_u)$ is the time t value of the job at the upper support of the distribution obtained from (29). Similarly, the empirical definition of job destruction is the sum (in absolute value) of all negative employment changes. Endogenously, negative employment changes come from those idle jobs that get firing permission. If we then assume that there is an exogenous turnover rate of δ, the job destruction is

$$JD_t = sI_t + \delta N_t, \tag{34}$$

where sI_t is job destruction via the firing permission and δN_t is job destruction by natural turnover [9].

To evaluate (34) we have to keep track over time of the switch in the composition of employment between operational and idle jobs. If we define I_{inft} as the inflow into the idle state at time t, it follows that:

$$I_{inft} = \lambda F(\epsilon_d(x_t))(N_t - I_t) + \Phi_3 \int_{\epsilon_d(x_{t-1})}^{\epsilon_d(x_t)} O_t(z)dz, \tag{35}$$

where Φ_3 is an indicator function taking value 1 if $\epsilon_d(x_t) \geq \epsilon_d(x_{t-1})$. Jobs flow into the idle state for two reasons: either an idiosyncratic shock below the current reservation productivity hits the job or the aggregate state worsens and makes idle all jobs whose productivity lies

[9] In the asset equations describing the value of a match (1) and (23), the presence of the natural turnover works exactly as the interest rate r and, for simplicity, it has been so far neglected.

between the two values. Vice-versa, if we define I_{out} as the outflow from the idle state between t and $t+1$:

$$I_{out} = (\lambda(1 - F(\epsilon_d(x_t))) + s)\, I_t + \Phi_4 \int_{\epsilon_d(x_{t-1})}^{\epsilon_d(x_t)} I_t(z)dz, \tag{36}$$

where Φ_4 is an indicator function that takes value 1 if $\epsilon_d(x_t) < \epsilon_d(x_{t-1})$. Jobs leave the idle state for three reasons: a positive idiosyncratic shock makes jobs fully operational, firing permission arrives or a positive aggregate shock makes all jobs between the two reservation productivities fully operational. Given the flows (32)-(36), obviously:

$$N_{t+1} = JC_t - JD_t + N_t, \tag{37}$$

and

$$I_{t+1} = I_{inft} - I_{iout} + I_t. \tag{38}$$

Let us consider a positive aggregate shock that switches the system from x_z to x_j and assume that $\theta_j > \theta_z$ and $\epsilon_j < \epsilon_z$. The intuition goes as follows. In (32) job creation increases as new vacancies are matched to unemployed through the matching function q. On impact, from I_{out}, the outflow from the idle state jumps since all idle jobs whose productivity lie between the two reservation productivities are now fully operational. The number of idle workers jumps downward and, for a given arrival rate s, job destruction next period will fall. The process continues as long as a new steady state with job creation equal to job destruction is reached or a new aggregate shock arrives. Let us now repeat the experiment for a negative aggregate shock from x_j to x_k, and assume that $\theta_k < \theta_j$ and $\epsilon_k > \epsilon_j$. Job creation falls as the number of vacancies opened falls, while on impact, the number of idle jobs jumps upward, since all operational jobs whose productivity lies between the two reservation productivities are now idle. For a given s in (34), job destruction next period will increase. Intuitively, in a boom (recession) job creation rises (falls) and job destruction falls (rises). Furthermore, the response of the two flows following a state switch should be symmetric. As new vacancies have to be matched to unemployed workers as conditions improve, so new idle workers need firing permission to destroy the job. The next Section simulates the solution of the general model for different values of firing permission s.

6 Model Simulation

To implement the general stochastic model of the previous Sections it is necessary to specify the process for $\{x_t\}$. The Markov chain is determined by the state space of x_t, χ, and the transition probability matrix Π. In this Section, as in Christiano (1990), we adopt the following three state model:

$$\Pi = \left\{ \begin{array}{ccc} \phi & \gamma & 1-\phi-\gamma \\ \Psi & 1-2\Psi & \Psi \\ 1-\phi-\gamma & \gamma & \phi \end{array} \right\},$$

and

$$\chi = \left\{ \begin{array}{c} -x \\ 0 \\ x \end{array} \right\}.$$

The Wold representation corresponding to this Markov chain is

$$x_t = \rho x_{t-1} + e_t, \tag{39}$$

where e_t is mean 0 with variance σ_e^2 and is uncorrelated with x_{t-1}. Furthermore,

$$\rho = 2\phi + \gamma - 1; \;\; \kappa = 1 + .5\gamma/\Psi, \tag{40}$$

where κ is kurtosis, and

$$var(x_t) = \frac{x^2}{\kappa}; \;\; \sigma_e^2 = var(x_t)(1-\rho^2). \tag{41}$$

To determine this model, values must be assigned to four parameters, ϕ,γ,Ψ and x. The simulations in this Section follow the lines of a recent paper by Millard and Mortensen (1994), who calibrate the MP model for the U.S. and U.K. economies under the assumption that the only difference between the two countries lies in the policy parameters and in the workers' bargaining strength. Thus, the baseline parameters values should be taken as representative of every country, independent of its labour market policies. In this direction the U.S. turns out to be the country with insignificant firing restrictions and we use parameter values very similar to MP (1993), where they solve the MP (1994) model without explicitly considering wage bargaining. As to the Markov chain parameters, we set $\phi = 0.933$, $\gamma = 0.067$ and $\Psi = 0.017$. As to the aggregate shock we let x be 0.008. These parameters imply a value of $\rho = 0.933$ - slightly less than what is generally used in the real business cycle literature - and a value of $\kappa = 2.97$, so as to approximate the kurtosis of the normal distribution. The productivity distribution is uniform over the interval [-1,1], the arrival rate of the idiosyncratic shock λ is set to 0.081, while σ, the dispersion of the productivity distribution is set to 0.037. The matching function, as in (33) is log linear with matching elasticity of unemployment α equal to 0.25 and coefficient k equal to 1. The real interest is set to 0.02. These parameter values are very similar to those chosen by MP (1993) and they are summarised in Table 4.

The most problematic parameter to set is s. From the Beveridge curve for the steady state model (19) it is clear that, given a value of λ equal to 0.08, a value of s of the order of 1 should not affect too much equilibrium unemployment directly. Numerical solutions show that a value of s of 1.2 implies an average equilibrium unemployment of 5.8% [10]. The corresponding correlation between job reallocation and net employment changes is, on average, $-.5$, the relative variance of job destruction and creation is 4 while the coefficients of variation are respectively 0.7 for job destruction and 0.4 for job creation. These values are in line with the statistics of job flows in United States, Canada and Britain reported in Tables 1 and 2 and we take them to be representative of an economy with insignificant firing restrictions.

Summary statistics for time series simulations are summarised in Table 5. For different values of firing restrictions we simulated 150 time series of 64 periods each. Job creation is pro-cyclical (correlation Jc-Net) and job destruction is countercyclical (corr. Jd-Net) for different values of s ranging from 1.2 to 0.2. As firing restrictions increase, both job creation and destruction fall, and, from the range of values of s chosen in Table 5, equilibrium unemployment is approximately constant. This result is similar to Mortensen and Millard (1994), who find that firing costs are responsible for less than 1 percent of the U.K. unemployment. The effect of linear firing costs on labour demand have recently been analysed by Bentolila and Saint-Paul (1994). They argue that labour demand is likely to increase only if firing restrictions are sufficiently high. In this respect the results in Table 5 seem to confirm the Bentolila and Saint-Paul finding, even though their model does not explicitly consider the effect of firing costs on unemployment.

The most important result in Table 5, in line with the spirit of Bertola (1990) is that firing restrictions, albeit not responsible for lower employment levels, dramatically affect labour market dynamics, through their effect on the relative volatility of job creation and job destruction. The relative variance of job destruction to job creation $\frac{\sigma^2_{JD}}{\sigma^2_{JC}}$ falls dramatically as firing restrictions increase. To falls in the relative variance correspond differences in the cyclical behaviour of job reallocation, which rises from negative to positive values. Overall, as the average waiting time for firing restrictions increases, the statistics in Table 5 replicate the dynamics of economies with serious or fundamental firing restrictions, as indicated in

[10] All the simulations of this paper have been obtained with a Gauss programme written by the author. The programme is available upon request.

Table 1 and 2.

A controversial result of Table 5 is the correlation between job creation and job destruction, which is not as negative as the one found in Table 1 and 2. This result is due to a too strong responsiveness of job creation to unemployment. Similar correlation is found in MP (1993). Mortensen (1994) introduces voluntary quits and obtains a negative correlation between job creation and job destruction. Other statistics of Table 5 show that as firing restrictions increase the average duration of unemployment increases. Firing restrictions obviously have a strong effect on average idle capacity, the average fraction of jobs waiting for firing permission. Finally Table 5 agrees with the econometric evidence on the effect of firing costs on the persistence of employment (Alogoskoufis and Manning, 1988). Employment adjusts more slowly with relatively high firing costs [11].

7 Conclusions

This paper has taken seriously the recent empirical studies on job creation and destruction collected by the OECD (1994a). Focusing on the cyclical properties of these flows, job creation is pro-cyclical while job destruction is countercyclical. Huge differences exist in the relative volatility of the two flows. This paper has offered a model that for different values of firing restrictions, implies both facts.

When firing permissions are continuously available, job destruction is instantaneous while job creation takes time and job reallocation moves countercyclically. As firing is restricted to be costly and time consuming, the asymmetry between job flows disappears and job reallocation is uncorrelated with net employment changes. This paper has argued that this mechanism is behind the cross-country variation in the cyclical behaviour of job flows.

Another implication of the model is that reasonable firing restrictions do not imply higher equilibrium unemployment, but they reduce both job creation and job destruction. Since these flows are equal in equilibrium, the effect on unemployment is ambiguous. It has already been recognized (Bertola 1990; Bentolila and Bertola 1990) that higher firing costs do not

[11] Another implication of the model that may be considered is the effect of firing restrictions on the cyclical behaviour of labour productivity. From the model stand-point the dynamics of labour productivity coincides with the dynamics of employment. In fact, if $p + \sigma\epsilon$ is output per worker in a job of productivity ϵ, average productivity is simply $(1-u)\int_{\epsilon_{lo}}^{\epsilon_u}(p+\sigma\epsilon)\, f(\epsilon)d\epsilon$. Over the cycle the integral in the previous expression is constant and the dynamics of employment implies that the higher the firing restrictions, the lower is employment variance and the lower is the cyclical behaviour of productivity. The empirical evidence, however, is much less clear. Fiorito and Kollintzas (1994), in their estimate of business cycles facts for the G7 countries, find that labour productivity is most volatile in Italy, Japan and U.K. and least volatile in France, with the U.S. and Canada somehow in an average position.

bias downward average employment, but they significantly affect labour market dynamics. In this paper, we have shown a way in which firing restrictions affect the volatility of job destruction and creation, an aspect of employment dynamics.

Several directions should be taken from this paper. Firstly, following Millard and Mortensen it is possible to distinguish the differential effect of firing restrictions on unemployment incidence and duration and to calculate the welfare effect of different degrees of firing restrictions. Secondly, along the line of the work of Burda and Wyplosz (1994) for Europe and of Mortensen (1994) for the U.S., it is necessary to investigate the effect of firing restrictions on worker flows. Thirdly, Hopenhayn and Rogerson (1993) simulate a general equilibrium model with simultaneous job creation and destruction and they find that a tax on job destruction has a sizable negative impact on total employment. With respect to the approach of this paper, Hopenhayn and Rogerson explicitly consider the effects of firing restrictions on labour supply decisions, completely neglected in this paper. Future research should try to model labour supply in a dynamic matching models.

A Appendix: The Dynamics of Job Destruction in a Special Case

This Section illustrates analytically how the dynamics of job destruction is affected by firing restrictions. In what follows we let the aggregate productivity parameter p take only a high value p^* when the economy is booming and a low value p when the economy is in recession, and we shall indicate with μ the instantaneous transition rate from one aggregate state to the other. Since job destruction is completely driven by the reservation productivity, we start describing the equations of the marginal jobs.

Applying the methodology of Section 4 to this simpler case and indicating with (ϵ_d) and (ϵ_d^*) the marginal productivity in bad and good times, the reservation productivity in recession solves

$$p + \sigma\epsilon_d - b = -\lambda E[J] - \mu J^*(\epsilon_d), \tag{I}$$

where

$$J^*(\epsilon_d) = \frac{p^* + \sigma\epsilon_d - b + \lambda E[J^*]}{r + \lambda + \mu}. \tag{II}$$

Conversely, the reservation productivity in a boom solves

$$p^* + \sigma\epsilon_d^* - b = -\lambda E[J^*] - \mu J(\epsilon_d^*), \tag{III}$$

where

$$J(\epsilon_d^*) = \frac{p + \sigma\epsilon_d^* - b + \lambda E[J]}{r + \lambda + \mu + s}. \tag{IV}$$

Equations (III) and (I) form a system of two equations in ϵ_d and ϵ_d^*.

The reservation productivity in recession in (I) is not directly affected by the firing restrictions s. If the state of the economy switches to boom the marginal firm will get a positive asset value and will ignore firing permissions if they arrive. Conversely, the introduction of s directly affects the reservation productivity during a boom in (III). If the economy switches from boom to recession the last term in (III) is positive as long as the marginal job must wait for a firing restriction and can not destroy a negatively valued asset.

Solving for the market tightness in recession and in boom, from a system analogous to (28) and (29), the model is determined by the couple (ϵ_d, θ) in a recession and (ϵ_d^*, θ^*) in a boom.

The analysis so far has concentrated only on the *direct* effect of s on the marginal productivity (II) and (IV). In general, the presence of firing restrictions affect the marginal productivity in (II) and (IV) also through its *indirect* effect on the average value of the jobs. For completeness of exposition, the expected value of a job in recession is

$$\begin{aligned} E[J] \quad &= \quad \frac{\sigma}{r+\lambda}\int_{\epsilon_d}^{\epsilon_u}(1-F(x))dx - \frac{\sigma(r+\lambda+2\mu)}{(r+\lambda+\mu)(r+\lambda+s)+\mu(r+\lambda)} \\ &\quad \int_{\epsilon_d^*}^{\epsilon_d} F(x)dx - \frac{\sigma}{r+\lambda+s}\int_{\epsilon_l}^{\epsilon_d^*} F(x)dx. \end{aligned} \tag{V}$$

Similarly, the expected value of a job during a boom reads

$$\begin{aligned} E[J^*] \quad &= \quad \frac{\sigma}{r+\lambda}\int_{\epsilon_d}^{\epsilon_u}(1-F(x))dx + \frac{\sigma(r+\lambda+2\mu+s)}{(r+\lambda+2\mu)(r+\lambda)+s(r+\lambda+\mu)} \\ &\quad \int_{\epsilon_d^*}^{\epsilon_d} F(x)dx - \frac{\sigma}{r+\lambda+s}\int_{\epsilon_l}^{\epsilon_d^*} F(x)dx. \end{aligned} \tag{VI}$$

In (V) s reduces the average value of a job during recession through the second and third term of (V). When $s \to \infty$ the second and the third term vanish, a job in recession is never idle and it is operative only in the interval between $(\epsilon_u - \epsilon_d)$.

Similarly, with no firing restrictions, the third term in (VI) vanishes and the expected value of a job in the boom becomes

$$\lim_{s\to\infty} E[J^*] = \frac{\sigma}{r+\lambda}\int_{\epsilon_d}^{\epsilon_u}(1-F(x))dx + \frac{\sigma}{r+\lambda+\mu}\int_{\epsilon_d^*}^{\epsilon_d}(1-F(x))dx.$$

The indirect effects of firing restrictions on the expected value of the jobs are similar to the steady-state effects of firing restrictions described in Section 3.2 and have no distinctive dynamic effects.

B Appendix: Firing Tax in Steady State

In this Section we model the behaviour of the firm under the assumption that firing costs take the form of a simple fixed firing tax of $-F$ to be incurred when separation takes place. The model is in the spirit of Mortensen and Millard (1994). In this case, the forward looking asset equation for a job at productivity ϵ reads

$$rJ(\epsilon) = p + \sigma\epsilon - b + \lambda\left(E(J) - J(\epsilon)\right). \tag{VII}$$

A firm hit by a negative idiosyncratic shock will keep running a job as long as its marginal value is greater than the fixed firing cost $-F$. Under this rule the marginal productivity solves

$$J(\epsilon_d^F) = -F, \tag{VIII}$$

where ϵ_d^F is the marginal productivity under the fixed firing rule. The average value of the job is

$$E[J] = \int_{\epsilon_l}^{\epsilon_d^F} -F dF(x) + \int_{\epsilon_d^F}^{\epsilon_u} J(x) dF(x), \tag{IX}$$

where

$$\int_{\epsilon_d^F}^{\epsilon_u} J(x) dF(x) = J(\epsilon_u) - J(\epsilon_d^F) F(\epsilon_d) - \frac{\sigma}{r+\sigma}\int_{\epsilon_d}^{\epsilon_u} F(x) dx. \tag{X}$$

Making use of (VIII), the value of a job at the upper support of the distribution reads

$$J(\epsilon_u) = -F + \frac{\sigma}{r+\lambda}\int_{\epsilon_d^F}^{\epsilon_u} dx,$$

and substituting this expression into (X), the average value of a job reads

$$E[J] = \frac{\sigma}{r+\lambda}\int_{\epsilon_d^F}^{\epsilon_u}\left(1 - F(x)\right) dx - F. \tag{XI}$$

From (XI) it is clear that, given the reservation productivity, firing costs reduce the average value of the job.

Making use of (VIII) and (XI), the reservation productivity solves

$$p + \sigma\epsilon_d^F - b = -\frac{\lambda\sigma}{r+\lambda}\int_{\epsilon_d^F}^{\epsilon_u}(1 - F(x))dx - rF. \tag{XII}$$

The right hand side of (XII) is negative and there is labour hoarding in the firm's optimal policy. Differentiating (XII) with respect to F yields

$$\sigma\frac{r + \lambda F(\epsilon_d^F)}{r+\lambda}\frac{\partial\epsilon_d^F}{\partial F} = -r. \tag{XIII}$$

Thus higher firing costs reduce the reservation productivity and induce the firm to hold on to less profitable jobs.

Firms post vacancies and, conditional upon finding an unemployed worker, they create a job at the upper support of the distribution $J(\epsilon_u)$. Free entry in equilibrium implies that

$$J(\epsilon_u) = \frac{c}{q(\theta)}. \tag{XIV}$$

In order to solve (XIV) for θ we need an expression for $J(\epsilon_u)$, the value of a job at the upper support of the distribution. If we evaluate (VII) at ϵ_u and subtract it from (XII), $J(\epsilon_u)$ reads

$$J(\epsilon_u) = \frac{\sigma(\epsilon_u - \epsilon_d^F)}{r+\lambda} - F. \tag{XV}$$

Differentiating (XIV) with respect to F, making use of (XV) and (XIII), yields

$$\frac{-\lambda F(\epsilon_d^F)}{r + \lambda F(\epsilon_d^F))} = -\frac{cq\prime(\theta)}{q(\theta)^2}\frac{\partial\theta}{\partial F}. \tag{XVI}$$

Since $q\prime(\theta) < 0$, job creation falls with the increase in the firing tax. Thus higher firing taxes reduce the job finding rate $\theta q(\theta)$.

Job creation is $\theta q(\theta)u$, and job destruction is $\lambda F(\epsilon_d)(1-u)$ and unemployment is obtained as a solution to

$$\dot{u} = \lambda F(\epsilon_d^F)(1-u) - \theta q(\theta)u. \tag{XVII}$$

Unemployment is constant when job creation equals job destruction and reads

$$u = \frac{\lambda F(\epsilon_d^F)}{\lambda F(\epsilon_d^F) + \theta q(\theta)}. \tag{XVIII}$$

Since higher firing costs affect both the job creation and job destruction decision, they have an ambiguous impact on equilibrium unemployment. Differentiating (XVIII) with respect to F, it is clear that the overall effect depends on the parameters of the model and the distribution of productivity $F(\epsilon_d^F)$. Total job reallocation is $2\lambda F(\epsilon_d^F)(1-u)$ and the derivative with respect to F depends on the ambiguous effect of firing costs on unemployment. Nevertheless, if we define job reallocation as the sum, in absolute value, of employment changes, over total employment, it follows that

$$JR = \lambda F(\epsilon_d^F). \tag{XIX}$$

Differentiating (XIX) with respect to F, and making use of (XIII), higher firing costs unambiguously reduce the job reallocation rate.

C Appendix: Job Destruction, Firing Tax and Cyclical Shocks

In this Section we extend the model of the previous Section to allow the aggregate productivity p to fluctuate stochastically between an high value p^* and a low value p, and we indicate with μ the switching probability between the two values. The model is in the spirit of Millard (1994). If we indicate with ϵ_d^F and ϵ_d^{F*}, the reservation productivity in bad and good times, the value of a job in recession, $J(\epsilon)$, for $\epsilon \geq \epsilon_d^F$ solves

$$(r+\lambda+\mu)J(\epsilon) = p + \sigma\epsilon - b + \lambda E(J) + \mu J^*(\epsilon). \tag{XX}$$

Similarly, a value of a job during a boom, $J^*(\epsilon)$, for $\epsilon \geq \epsilon_d^F$ solves

$$(r+\lambda+\mu)J^*(\epsilon) = p^* + \sigma\epsilon - b + \lambda E(J^*) + \mu J(\epsilon). \tag{XXI}$$

Finally, for $\epsilon_d^{F*} < \epsilon < \epsilon_d^F$, the value of a job during a boom solves

$$(r+\lambda+\mu)J^*(\epsilon) = p^* + \sigma\epsilon - b + \lambda E(J^*) - \mu F. \tag{XXII}$$

Proceeding in the same way as in Section 4, the expected value of a job during recession is

$$E(J) = \frac{\sigma}{r+\lambda}\int_{\epsilon_d^F}^{\epsilon_u}(1-F(x))dx - F, \tag{XXIII}$$

and the expected value of a job during the boom is

$$E(J^*) = \frac{\sigma}{r+\lambda}\int_{\epsilon_d^F}^{\epsilon_u}(1-F(x))dx + \frac{\sigma}{r+\lambda+\mu}\int_{\epsilon_d^{F*}}^{\epsilon_d^F}(1-F(x))dx - rF. \tag{XXIV}$$

Using (XXIII) into (XX) and evaluating (XX) at $J(\epsilon_d) = -F$, yields

$$p + \sigma\epsilon_d - b = -\frac{\lambda\sigma}{r+\lambda}\int_{\epsilon_d^F}^{\epsilon_u}(1-F(x))dx - \frac{\mu\sigma(\epsilon_d^F - \epsilon_d^{F*})}{r+\lambda+\mu} - rF. \tag{XXV}$$

Proceeding similarly for $J(\epsilon_d^{F*}) = -F$ yields

$$p^* + \sigma\epsilon_d^{F*} - b = -\frac{\lambda\sigma}{r+\lambda}\int_{\epsilon_d^F}^{\epsilon_u}(1-F(x))dx - \frac{\lambda\sigma}{r+\lambda+\mu}\int_{\epsilon_d^{F*}}^{\epsilon_d^F}(1-F(x))dx - rF. \tag{XXVI}$$

Proceeding as in Section 4 it is possible to obtain market tightness in boom (θ^*) and in recession (θ). Consider first what happens when the aggregate productivity switches from p to p^*. On the one hand, firms open up more vacancies, on the other hand firms hold on to more existing jobs ($\epsilon_d^{F*} < \epsilon_d^F$). On impact neither job destruction nor job creation jumps, since new vacancies take time to be matched to unemployed workers. As matching takes place, the fall in unemployment induces a fall in job creation and an increase in job destruction until there is convergence to a new steady-state, or until there is a new cyclical shock. When aggregate productivity falls from p^* to p the dynamics of job creation follows an opposite pattern to the one after an increase in p: vacancies fall on impact, but job creation takes time to fall. Conversely, since all jobs whose productivity lies between ϵ_d^{F*} and ϵ_d^F will immediately be destroyed, there will be an immediate spike in job destruction. This increase in job destruction has no counterpart in the behaviour of job destruction when p increases, or in the behaviour of job creation during expansions. Thus, with a fixed firing cost rule, the variance in job destruction is bound to be higher than the variance in job creation, exactly as in the MP (1994) model.

References

Albaek, K. and B. E. Sorensen, 1995, Worker flows and job flows in danish manufacturing, 1980-91, Discussion Paper 95-12, Institute of Economics, University of Copenhagen.

Alogoskoufis, G. and A. Manning, 1988, On the persistence of unemployment, Economic Policy 7, 428-469.

Baldwin J., T. Dunne and J. Haltiwanger, 1994, A comparison of job creation and job destruction in Canada and the United States, National Bureau of Economic Research, Working Paper 4726.

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

Bentolila, S. and G. Saint-Paul, 1994, A model of labor demand with linear adjustment costs, Labour Economics 1, 303-326.

Bertola, G., 1990, Job security, employment and wages, European Economic Review 34, 851-886.

Bertola, G. and R. Rogerson, 1996, Institutions and labor reallocation, University of Turin, Unpublished.

Blanchflower, D. G. and S. M. Burgess, 1994, Job creation and job destruction in Britain: 1980-90, Centre for Economic Policy Research, Discussion Paper 912.

Boeri, T. and U. Cramer, 1993, Why are establishments so heterogeneous?, OECD, unpublished.

Boeri, T., 1995, Is job turnover counter cyclical?, Università Bocconi, unpublished.

Burda, M., 1992, A note on firing costs and severance benefits in equilibrium unemployment, Scandinavian Journal of Economics 94, 479-489.

Burda, M. and C. Wyplosz, 1994, Gross worker and job flows in Europe, European Economic Review 38, 1287-1313.

Christiano, L. J., 1990, Linear-quadratic approximation and value- function iteration: a comparison, Journal of Business & Economic Statistics 8, 99-113.

Contini, B., R. Revelli, A. Gavosto and P. Sestito, 1992, Creazione e distruzione di posti di lavoro in Italia, Banca D'Italia, Temi di discussione del servizio studi 177.

Davis, S. J., and J. Haltiwanger (1990), Gross job creation and destruction: microeconomic evidence and macroeconomic implications, NBER Macroeconomic Annual 5, 123- 168.

Davis, S. J., and J. Haltiwanger, 1992, Gross job creation, gross job destruction and employment reallocation, Quarterly Journal of Economics 107, 819-863.

Davis, S. J., J. Haltiwanger and S. Shuh, 1996, Job Creation and Destruction (MIT Press, Cambridge).

Diamond, P. A., 1971, A model of price adjustment, Journal of Economic Theory 3, 156-168.

Emerson, M., 1988, Regulation or deregulation of the labour market, European Economic Review 32, 775-817.

Fiorito, R. and T. Kollintzas, 1994, Stylized facts of business cycles in the G7 from a real business cycles perspective, European Economic Review 38, 235-269.

Garibaldi, P., (1996), Job creation, job destruction and employment reallocation. Theory and Evidence, Ph.D. dissertation, London School of Economics, unpublished.

Garibaldi, P., J. Konings and C. A. Pissarides, 1997, Gross job reallocation and labour market policy, in: D.J. Snower and G. de la Dehesa, eds., Unemployment policy: how government should respond to unemployment?, (Cambridge University Press,Cambridge).

Grubb, D., and W. Wells, 1993, Employment regulation and patterns of work in EC countries, OECD Economic Studies 21, 7-59.

Hopenhayn, H. and R. Rogerson, 1993, Job turnover and policy evaluation: a general equilibrium analysis, Journal of Political Economy 101, 915-938.

Konings, J., 1995, Job creation and job destruction in the U.K. manufacturing sector, Oxford Bulletin of Economics and Statistics 57, 5-24.

Lagarde, S., E. Maurin and C. Torelli, 1994, Job Reallocation Between and Within Plants, INSEE, Direction Statistique Demographique et Social, unpublished.

Millard, S. P., 1994, The effect of employment protection legislation on labour market activity: a search approach, Bank of England, unpublished.

Millard, S. and D. T. Mortensen, 1994, The unemployment and welfare effects of labour market policy: a comparison of the U.S. and the U.K., Bank of England, unpublished.

Mortensen, D. T., 1991, The persistence and indeterminacy of unemployment in search equilibrium, Scandinavian journal of economics 93, 347-370.

Mortensen, D. T., 1994, The cyclical behaviour of job and worker flows, Journal of Economic Dynamics and Control 18, 1121-1142.

Mortensen, D. T. and C. A. Pissarides, 1993, The cyclical behaviour of job creation and job destruction, in: J.C. van Ours, G.A. Pfann and G. Ridder G, eds., Labor Demand and Equilibrium Wage Formation, (North Holland,Amsterdam).

Mortensen, D. T. and C. A. Pissarides, 1994, Job creation and job destruction in the theory of unemployment, Review of Economic Studies 61, 397-415.

OECD, 1994a, Job gains and job losses in firms, OECD Employment Outlook, 103-166.

OECD, 1994b, Job Study, Vol. 2.

Pissarides, C. A. 1985, Short-run equilibrium dynamics of unemployment, vacancies and real wages, American Economic Review 75, 676:690.

Pissarides, C. A., 1990, Equilibrium unemployment theory, (Basil Blackwell, Oxford).

R&P, 1995, A study on job creation and job destruction in Europe, study for the Commission of the European Communities D.G.V., Unpublished.

Salvanes, K. G., 1995, The flexibility of the Norwegian labour market: Job creation and job destruction in manufacturing 1977-86, Discussion paper 12/95,Norwegian School of Economics.

Table 1: Correlation Between Gross Job Flows and Net Employment Changes

Country	Corr. $JC-NET$ (a)	Corr. $JD-NET$ (b)	Corr. $JC-JD$ (c)	Corr. $JR-NET$ (d)	Time Period
U.S.	0.90 (0.00)	-0.958 (0.00)	-0.745 (0.00)	-0.519 (0.003)	1973-88
Canada	0.82 (0.00)	-0.89 (0.00)	-0.47 (0.08)	-0.252 (0.38)	1973-86
U.K.	0.85 (0.00)	-0.99 (0.00)	-0.78 (0.00)	-0.95 (0.00)	1973-86
Denmark	0.97 (0.00)	-0.97 (0.00)	-0.88 (0.00)	0.03 (0.90)	1980-91
Germany	0.93 (0.00)	-0.95 (0.00)	-0.78 (0.01)	-0.04 (0.89)	1977-90
Norway	0.79 (0.00)	-0.84 (0.00)	-0.35 (0.01)	-0.13 (0.89)	1977-86
Italy	0.79 (0.00)	-0.81 (0.00)	-0.28 (0.42)	-0.13 (0.88)	1984-93
France	0.97 (0.00)	-0.85 (0.01)	-0.83 (0.01)	0.74 (0.05)	1984-92
Sweden	0.97 (0.00)	-0.95 (0.01)	-0.86 (0.01)	0.49 (0.25)	1984-92

(a) Spearman correlation between job creation (JC) and net employment changes (NET)

(b) Spearman correlation between job destruction (JD) and net employment changes (NET)

(c) Spearman correlation between job creation (JC) and job destruction (JD)

(d) Spearman correlation between job reallocation (JR) and net employment changes (NET)

Marginal significance in parenthesis

Source: United States, Davis, Haltiwanger ans Shuh (1996);
United Kingdon, Konings (1995); Canada, Baldwin et al. (1994);
Norway, Salvanes (1995); Germany, Boeri and Cramer (1993);
Italy, R&P (1995); France, Lagarde et al.(1994);
Sweden, OECD (1994a) ;Denmark, Albaek and Sorensen (1995)

Table 2: Variance of Gross Job Flows

Country	$\frac{\sigma^2_{JD}}{\sigma^2_{JC}}$ (a)	$\frac{\sigma^2_{JC}}{JC}$ (b)	$\frac{\sigma^2_{JD}}{JD}$ (c)
U.S.	2.40	0.24	0.33
Germany	1.00	0.10	0.11
Canada	1.55	0.17	0.22
Italy	1.09	0.10	0.12
Denmark	0.98	0.13	0.13
U.K.	17.8	0.52	0.63
Sweden	0.56	0.14	0.11
France	0.39	0.11	0.08
Norway	1.39	0.22	0.29

(a) Variance of job destruction (σ^2_{JD}) over variance of job creation (σ^2_{JC})

(b) Coefficient of variation of job creation

(b) Coefficient of variation of job destruction

Source: see sources of Table 1

Table 3: Importance of Procedural Constraints

Rank	Country	Strictness
1	U.S.	0.4
2	U.K.	0.5
3	Canada	0.6
4	Denmark	1.0
5	Norway	1.5
6	Sweden	2.0
7	France	2.0
8	Germany	2.5
9	Italy	3.0

Ranking from least restrictive to most restrictive

ILO classifies regulatory constraint as

-insignificant (scored 0);

-minor (for termination of regular contracts),

insignificant or minor (for fixed-term contracts) (both scored 1);

-serious (scored 2); -fundamental (scored 3)

Source: OECD (1994b)

Table 4: Baseline Parameter Values

Variables	Notation	Value
Matching Elasticity	α	0.250
friction parameter	k	5
net common price	x_1	0.008
net common price	x_2	0.0
net common price	x_3	-0.008
interest rate	r	0.020
natural turnover	δ	0.020
idiosyncratic shock rate	λ	0.081
price dispersion	σ	0.037
price distribution	$F(.)$	uniform
upper support	ϵ_u	1
lower support	ϵ_{lo}	-1
Markov chain probability	ϕ	0.933
Markov chain probability	γ	0.017
Markov chain probability	Ψ	0.067
firing restrictions (max)	s	1.20
firing restrictions (min)	s	0.05

Source: Christiano (1990), Mortensen (1994), Mortensen Pissarides (1993) and author calculations.

Table 5: Simulation Statistics

	$s = 1.20$	$s = 1.00$	$s = 0.80$	$s = 0.60$	$s = 0.40$	$s = 0.20$
correlation JC_t, NET_t	0.617	0.607	0.592	0.598	0.644	0.776
correlation JD_t, NET_t	-0.814	-0.735	-0.704	-0.607	-0.592	-0.374
correlation JC_t, JD_t	-0.157	-0.018	0.078	0.200	0.190	0.242
correlation JR_t, NET_t	-0.502	-0.367	-0.267	-0.120	-0.007	0.368
$\sigma^2_{JD}/\sigma^2_{JC}$	4.051	2.422	1.676	1.030	0.594	0.204
$\sigma_{JC}/\overline{JC}$	0.377	0.344	0.328	0.315	0.281	0.276
$\sigma_{JD}/\overline{JD}$	0.750	0.588	0.489	0.395	0.301	0.202
$\overline{JC}$ rate	2.776	2.728	2.720	2.634	2.598	2.287
Unemployment	0.058	0.058	0.058	0.057	0.059	0.053
Duration Unemployment	2.035	2.046	2.063	2.091	2.218	2.321
Idle capacity	0.022	0.026	0.033	0.042	0.063	0.109
persistence unemployment	0.610	0.731	0.793	0.881	0.905	0.940