JOB SECURITY AND TRAINING: THE CASE OF PARETO IMPROVING FIRING TAXES

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Abstract

This paper shows that the under-investment in firm financed training caused by hold up can justify the introduction of firing taxes in a *laissez-faire* economy with search frictions and risk neutral agents. More precisely we highlight two results. First, the introduction of a firing tax for newly hired workers combined with hiring subsidies, always acts as a Pareto improving policy. Second, with no hiring subsidies, the introduction of a firing tax for the newly hired always increase the welfare of employed while its impact on the welfare of unemployed depends on the returns to training. We also analyze the implications of such a policy if a minimum wage is binding for newly hired workers.

**JEL classification**: J41, J63, J8

**Keywords**: employment protection, training, hold-up, welfare.
1. Introduction

Employment protection has been extensively analysed in recent decades, a period during which a number of European countries have enacted labour market reforms aimed at reducing the increase of unemployment. Most contributions have considered employment protection as a cost incurred by firms, and the focus has been on employment and labour market flows. Among these, Bentolila and Bertola (1990) explained the opposite mechanism through which firing costs prevent layoffs and discourage hiring, with ambiguous overall impact on employment. Other papers examine the relationship between the job security provisions and labour market flows obtaining similar conclusions (Bentolila and Dolado, 1994; Bertola and Rogerson, 1997; Garibaldi, 1998; Hopenhayn and Rogerson, 1998; Mortensen and Pissarides, 1999; Garibaldi and Violante, 2005).

However, employment protection affects human capital accumulation, productivity and welfare, not only the labour market flows. For example, Wasmer (2006) uses a matching model to show that employment protection shifts human capital accumulation towards specific skills by reducing turnover. He assumes that at entry into a job, workers decide about which type of skills they learn. Workers can afford investing in firm specific skills when the employment relationship is expected to last. By contrast, workers tend to invest much more in general skills rather than in firm specific skills when they perceive a high risk of losing their jobs, as in the case in the absence of employment protection.

Further some recent papers show that the non contractibility of the behaviour economic agents may legitimate the existence of employment protection to favour the accumulation of firm specific skills and welfare (Belot, Boone and van Ours, 2007; Booth and Zoega, 2003; Suederkum and Ruehmann, 2003; Estevez-Abe et al., 2001; Layard and Nickell, 1999; Teulings and Hartog, 1998).

Among these, Belot, Boone and van Ours (2007) present a search model in which firing costs reduce moral hazard in workers’ effort and stimulate firm specific skill acquisition by increasing job stability and, hence, raises social welfare. In this framework, assuming that worker is liquidity constrained and that capital markets are imperfect, the contractual solution to under-investment in firm specific skill is not feasible and, hence, government intervention imposing firing restrictions is justified.

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3 Thus, Wasmer (2006) argues that it is difficult to Pareto-rank countries with large employment protection and specific skills on the one hand (e.g. Europe), and low employment protection and general skills on the other hand (e.g. United States), as both equilibria have pros and cons in steady-state.
Actually, the analysis of the relationship between optimal job duration and the accumulation of firm specific skills in labour market with imperfect information draws back to Hashimoto (1979,1981). In particular Hashimoto (1979,1981) presents a model where potentially unverifiable match specific productivity shocks and the hold-up problem in training investment may lead to social inefficiency, that is a suboptimal job duration and under provision of firm specific skills. In this context he does not discuss the potential advantages of employment protection legislation because of social optimum can be obtained by assuming that workers are allowed to share the cost of training through a wage cut in the first period of employment relationship and that firm investment in training is observable and, presumably, verifiable.

Our paper makes two main contributions to this strand of literature. First, we present a general equilibrium model in which firing taxes may increase social welfare by reducing the hold up in firm financed training rather than by favouring the workers' effort expended acquiring firm-specific skills. This argument allows us to justify the introduction of firing taxes without assuming liquidity constraints and imperfect capital markets. Our results are then robust to criticism that innovative contractual arrangements can solve the under provision of firm financed training. Second, we demonstrate that an efficient use of firing taxes for newly hired workers and hiring subsidies is a Pareto improving policy. A result stronger than the welfare improving effect of employment protection already found in the literature.

To illustrate these issues we use a discrete-time matching model a la Mortensen-Pissarides (1994), in which the firms finance the training of their employees. The key hypothesis is that training cannot be contracted between firms and workers because of the unverifiable and unenforceable nature of firm specific human capital. The contractual incompleteness implies a moral hazard problem, as firms maximize their expected profits without considering the share of initial cost sustained by newly hired workers through a wage cut. In a laissez-faire economy this implies an under-investment equilibrium in firm financed training and, in turn, excessive layoffs, and lower job creation and welfare with respect to the social optimum. Further, wage renegotiation does not eliminate this inefficiency because of the timing of events. The amount of training is chosen in first stage of employment relation, while the returns to investment are realized at second stage. Thus workers are not able to affect the amount of training, which is chosen unilaterally by firms.

In this economy, the introduction of a firing tax for newly hired combined with the use of hiring subsidies, always increases firm financed training, job duration, and labour market tightness. This acts as a Pareto improving policy as it causes an increase of both the welfare of unemployed and employed workers without reducing the welfare of entrepreneurs who enter freely. In case of no hiring subsidies, the introduction of a firing tax for newly hired workers always increases the welfare of
employed by favouring increased training and job duration, even though its impact on the welfare of unemployed depends on the elasticity of the training function. However we provide a numerical example where a small firing tax for newly hired workers increases the welfare of unemployed in the case of no hiring subsidies.

We also consider the impact of the firing tax on labour market equilibrium when a minimum wage is binding for newly hired workers. In this case, the introduction of firing tax for newly hired workers increases training, job duration and the welfare of employed both in the presence of hiring subsidies and with no subsidies. However no analytical results may be obtained regarding the relationship between the firing tax and welfare of unemployed.

The paper is organized as follows. In section 2 we illustrate some stylized facts about the relationship between employment protection, new hires and the accumulation of firm-specific skills and the motivation of the paper. Section 3 describes the hypothesis of the matching model. Section 4 analyzes on the labour market equilibrium with different wage setting institutions. Section 5 analyses the comparative statics. Section 6 provides a numerical exercise to support our theoretical results. In Section 7 we discuss the social welfare analysis. Section 8 concludes. The appendix contains the proofs.

2. Empirical Literature and motivation of the paper

A number of comparative studies have investigated how firing costs may affect welfare by favouring firm specific skills accumulation and productivity growth. For example, Layard and Nickell (1999) perform a cross country analysis over the period 1976-1992 for which it appears that employment protection is the only institution that has a positive effect on labour productivity growth in OECD countries. The explanation they provide is that firing costs favour job stability and this, in turn, affect positively on the job training and productivity improvements.

Belot et al. (2007) use cross country analysis by using five year average data from seven time periods between 1960 and 1994 on the growth of GDP per capita and EPL index. Then they find that EPL does not have a linear effect on economic growth in OECD countries. At low levels of employment protection, an increase in protection stimulates human capital skills and growth, at high levels of employment protection, an increase in protection disincentive workers effort and it is harmful to growth. Then, there will be an optimal level of employment protection such that over some range increasing employment protection raise welfare which depends on other labour

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4 The index of employment protection used by Belot et al. (2007) combines information with respect to open-ended contracts, fixed-term contracts and temporary work agencies. An higher value of the indicator denotes stricter employment protection.
institutions. This finding is coherent with their theoretical model which predicts an inverse U relation between firing costs and the workers’ effort to increase the efficiency of employer-employee matches.

Other empirical studies are based on industry-level cross-country data. Bassanini, Nunziata and Venn (2009) adopt a difference in difference approach to investigate the relationship between employment protection and total factor productivity growth for 16 OECD countries over a period 1992-2003. Interestingly, they find that firing restrictions on regular contracts exerts a negative impact on total factor productivity growth, especially in sectors where firing costs are more binding, while the estimated effect of stricter regulations for temporary contracts on productivity growth is zero or positive.

Damiani, Pompei and Ricci (2011) develop this issue by analysing the relationship between temporary job protection and productivity growth in European economies over a period 1995-2007, that is a period over which reform at the margin have changed the labour market in Europe. Damiani et al (2011) use a difference in difference approach on cross-country industry-level data and find quite different results from those of Bassanini et al (2009). In particular, they demonstrate that deregulations of temporary contracts negatively influence the growth of total factor productivity and this negative effect is greater in industries where firms are more used to open short term positions. By contrast, restrictions on regular contracts do not induce significant impacts on total factor productivity growth.

The findings of Bassanini et al. (2009) and Damiani et al. (2011) illustrate a key feature of labour markets in many OECD countries: the fact that the employment protection legislation is not equal for all workers, being substantially lower for workers hired on fixed term contracts than for workers under permanent contracts. In particular, many European governments have enacted partial EPL reforms in the last two decades, weakening regulations on fixed-term contracts and maintaining strict firing costs on permanent contracts (OECSE, 2004).

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5 In particular, Bassanini et al(2009) use a difference-in-differences approach by using industry level US layoff rates as proxy for underlying layoff propensity in the absence of employment protection. As measures of strictness of dismissal regulations they adopt an index of employment protection for temporary contracts and an index o for temporary contracts and an overall index. The countries under study are: Austria, Belgium, Denmark, Finland, France, Germany, Italy, Netherlands, Spain, United States, United Kingdom, Czech Republic, Hungary, Japan, Poland and Sweden).

6 In 2008 over 14 percent of the total employees in the countries of the European Union had fixed term contracts. This percentage was significantly higher in Spain and Portugal where the share of employees with a contract of limited duration was about 26 and 22 per cent, respectively (Eurostat, 2010). The diffusion of fixed term contracts has completely changed the nature of employment relationships for young and newly hired workers in Europe. For instance, the share of fixed term contracts in newly created jobs in the 1990s have been about 80% in France and Spain (Cauch and Postel-Vinay, 2002). In Italy the share of fixed term
The diffusion of fixed term contracts recently at centre stage of the economic debate concerning their effectiveness on microdata. On one hand, it is suggested that by making it possible to hire workers on temporary basis, fixed term contracts tend to provide young workers with a stepping stone towards permanent employment (Booth, Francesconi and Frank, 2002 for United Kingdom; Contini, Pacelli and Villosio, 1999 for United Kingdom, Germany and Italy; Boeri and Garibaldi, 2007, for Italy). On the other, there is increasing evidence that they might represent a dead end in that they confine young and/or newly hired workers at the margin of the labour market, trapped in bad jobs characterized by repeated spells of unemployment, low wage and low incentives to invest in firm-specific skills (Guell and Petrongolo, 2007, for Spain; Blanchard and Landier, 2002, for France). That is, new forms of flexible employment may be detrimental to social welfare if they cause excessive turnover and under valuation of human capital investment by shortening agents’ time horizons.

There is comparative empirical evidence supporting this argument (Arulampalam and Booth, 2005; Brunello et al., 2005). Among these, Brunello et al. (2005) show that the fixed term contracts have a negative effect on the probability both of obtaining any training and of receiving employer sponsored training in Europe. In particular, using European Community Household Panel (ECHP) data from 1995 to 2001 and pooling all available observations over countries and time, Brunello et al. (2005) find a negative effect of -3.4 percentage points for employer sponsored training with respect to those employed with permanent (open-ended) contracts while the negative effect is lower for all training, being of about -2.4 percentage points. This result suggests a trade off between the diffusion of fixed term contracts and firm-specific skill acquisition of the employees, as the most of work-related training in Europe is sponsored by firms (Brunello et al. 2005). Further it offers, from a microeconomic perspective, a possible explanation for the negative relationship between the two-tier labour market reforms in employment protection carried out in several European countries and the decline of labour productivity growth in these countries between the mid-1980s and the 2000s (Damiani, Pompei and Ricci, 2011).

For what regard the motivation of the paper, our effort is to address this empirical evidence into a general equilibrium model which formalizes a typical situation faced by young and newly hired workers in Europe. That is, a situation where the worker accepts a low paid job under a fixed term contract (and no firing costs) with the opportunity of receiving some training financed by the firm. The implicit promise is that firm and workers re-negotiate the initial (low wage) contract when the returns to training are realized, giving higher wages and more job stability. In such a situation there are two main reasons why the workers cannot pay part of the cost of training by accepting a wage cut when newly hired. One reason is that the initial wage after the cut contracts among new hires grew from 34% to 42% between 1993 and 2003 (Cipollone and Guelfi, 2003).
is lower than the minimum wage set by law and, hence, illegal. Another reason is that contracts in which workers pays for training are vulnerable to moral hazard on the part of the firm, and are not enforceable in court. The risk is that the firm would promise to provide training but would not, in fact, train. Since training is often of the form of working under supervision, it is difficult for a labour judge to decide if a worker has been trained. Now, if the contract in which a worker pays for training is not enforceable, untrained workers may demand the same wage whether or not the firm promises to train them. This means that the firm will train less than would be socially optimal.

In such a situation our analysis aim to show that a well designed policy which combines firing taxes for newly hired and hiring subsidies acts as a Pareto improving intervention in a number of European labour markets

3. THE MODEL

The economy is populated by a continuum of risk-neutral workers and risk-neutral firms. All agents discount the future at the exogenous rate $r$, which is strictly positive, and enjoy the consumption of the only good of this economy. Time is discrete, $t=1,2,3,\ldots$

Firms post vacancies at a cost $k$ per period while workers supply labour inelastically and search with fixed intensity. The number of workers and firms that match is determined by a matching function $m(u,v)$, where $u$ is the number of unemployed workers, $v$ is the number of vacancies and the ratio $\theta = \frac{v}{u}$ is labour market tightness.

Then the probability that a firm will find an unemployed worker is $m(1,\theta) = m(\theta)$, while the probability of an unemployed worker to find a job is $m(\theta^{-1},1) = \theta m(\theta)$. The fraction $(1 - m(1,\theta))$ of workers that are not matched remain unemployed and do not receive unemployment benefits. We assume a constant flow of $\zeta$ new workers each period. These new workers start out unemployed. Workers are ex-ante homogenous in terms of ability.

Upon matching, the employment relation is modelled with a two stage structure, to highlight firms’ incentives to train in the early period of their employees’ career.

In the first stage, the initial productivity of a matched worker is equal to the expected value of the idiosyncratic productivity $\varepsilon$, distributed according to a continuous and differentiable function $F(\varepsilon)$ over the finite support $[\varepsilon_l, \varepsilon_u]$: $y_0 = E(\varepsilon) = \varepsilon^\varepsilon$. In addition, firms can train employees, to increase the future productivity of the match. In the model training is firm specific in the sense that the worker cannot use his skills with any other firms. The cost of training is linear and is incurred in terms of lower output in the first period of the match: $c(h) = h$ where $h$ is
the amount of training. The returns of training are realized in the later stage of the employment relationship, if the worker-employer pair is not dissolved. In this case training returns are defined by a differentiable function, \( f(h) \), with positive and decreasing marginal returns, i.e. \( f'(h) > 0 \) and \( f''(h) < 0 \). To find a parametric specification of the equilibrium we further assume that training returns equal to \( f(h) = ah^a \), where \( a > 0 \) is an efficiency parameter and \( 0 < a < 1 \) guarantees the concavity of the function.

At the start of second stage the employer-employee matches face a productivity change. In the case the employment relationship survives into an “insider” phase, the match productivity increases by the returns of training, i.e. \( y_1 = \varepsilon + ah^a \). In the case of separation, the firm returns in the labour market to fill a new vacancy position and workers become unemployed. The match is no longer subject to productivity shocks after the second period. Experienced workers retire from the labour market with probability \( s \) each period, with \( 0 < s < 1 \).

### 3.1 Public policy

We consider the possibilities of a firing penalty or tax which must be paid by the firm if the firm and the worker separate. We assume that no penalty is paid if an experienced worker retires, but that a penalty is paid if the experienced worker is laid off (this is important because the possible penalty affects wage bargaining). Importantly, the penalty is paid if firms and workers separate after just one period of employment, that is, if they separate as soon as \( \varepsilon \) is observed. In equilibrium workers are fired after one period or employed until they retire so all penalty payments actually paid are for separations after one period, that is, by firms which fire workers as soon as they observe \( \varepsilon \).

In modelling public policy we assume that the benchmark case is an economy with an initial laissez-faire equilibrium. In this context, the government decides whether to introduce a constant firing tax, \( T \), for firms which fire workers who were unemployed

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7 Additive returns of training simplify analysis without affecting the results; moreover, they highlight that firm-sponsored training does not arise because of complementary between training and match specific productivity (see Acemoglu and Pischke, 1999).

8 Thus the penalties which we consider are not like many existing firing penalties often allow firing without penalty at the end of a probationary period often identified with the period in which workers are trained. Hypothetically, one might imagine a different model than the one presented and analysed here, in which training takes two periods, productivity shocks are observed each period, and firing without penalty is allowed after one period. This would needlessly complicate the analysis, but would not eliminate the effects we consider.
when the policy reform was enacted. No separation cost is borne if firms fire workers already employed before the firing tax is introduced\(^9\).

Two different policy designs are examined. In the first case, the introduction of the firing tax is offset by a constant amount of employment subsidy, \( \sigma \), that the firms receive each time a worker is hired. This type of policy is designed in such a way that the present value of tax revenues is equal to the present value of subsidies, i.e. the public sector satisfies the inter-temporal budget constraint. In particular the amount of hiring subsidies compensate exactly the present value of the cost of separation sustained by firms for firing newly hired workers so that no fiscal externalities arise in equilibrium\(^{10}\). In the second case, there are no hiring subsidies and the public financing constraint does not bind. As a consequence, the introduction of a separation cost for firing newly hired workers are pure waste from social point of view.

### 3.2 Asset values

Consider the asset value equations that characterize firms and workers. Let \( J_o(\varepsilon, h) \) be the expected present value of the profit from a position filled as an entry level job, \( J_1(\varepsilon, h) \) the value of a regular job to the firm, and \( V \) the value of a vacancy to the firm:

\[
\begin{align*}
(1) \quad & J_o(\varepsilon, h) = \varepsilon - h - w_o(\varepsilon, h) + \sigma \frac{1}{1+r} \int [\text{Max}[J_1(\varepsilon, h), V - T]] dF(\varepsilon) \\
(2) \quad & J_1(\varepsilon, h) = \varepsilon + ah^s - w_1(\varepsilon, h) + \frac{1}{1+r} \{(1-s)J_1(\varepsilon, h) + sV\} \\
(3) \quad & V = \frac{-k}{1+r} + \frac{1}{1+r} \left\{ m(\theta)J_o(\varepsilon, h) + (1-m(\theta))V \right\}
\end{align*}
\]

In equation (1) the first term on the right is the flow of profit reduced by the cost of training and augmented by the employment subsidy \( \sigma \geq 0 \) that the firm receives each time a new worker is hired. The second term represents the capital gain associated with the option value to enter into a second stage of the match, after that the productivity change is realized at the end of the first stage. The integral term in equation (1) reflects the expected value of the profit to the firm if the employment relationship continues into the next period, otherwise the firm pays the firing tax

\(^9\)In our model the tax paid on separation is not a compensation given to the newly hired worker but a loss borne entirely by the firm. In reality employment protection regulation has other components, such as severance payments. Severance payments are pure transfers in wage bargaining, so they do not affect the financing of training by firms.

\(^{10}\)In the period when the policy is introduced, no workers hired after the introduction of the policy are fired (since they are all in training). The government borrows to pay the first round of subsidies and collects exactly enough revenue to repay its debt when some of the workers whose hiring was subsidized are fired. This makes the public budget constraint both simple and somewhat counter-intuitive.
\( T \geq 0 \) and returns to the market with a new vacancy\(^{11}\).

In equation (2) the first term on the right is the flow of profit given by the sum of the idiosyncratic productivity, \( \varepsilon \), and the returns to training. The second term in equation (2) represents the expected value of the profit associated with the exogenous probability that worker retires from the labour market. In particular, with probability \( (1-s) \) the productivity of the match is constant, otherwise the worker retires and the firm open a new vacancy.

Equation (3) is standard. The first term on the right is the flow cost of an open vacancy, \(-k\). The second terms is the expected profit given by the sum of the probability of hiring a worker times the asset value of an entry level job and the probability of the job remaining vacant times the asset value of the vacancy. It is worth to note that equations (1) to (3) the instantaneous profits at each stage and the flow cost to open a vacancy are discounted by \((1+r)\) because we assume that flow measure of revenues and costs of the firms are realized (and paid) at the end of the first stage of the match.

Turning to the asset value equations for a worker, let \( E_o(\varepsilon^*, h) \) denotes the expected present value of utility of newly hired workers, \( E_r(\varepsilon, h) \) the value of being employed in a regular job and \( U \) the value of being unemployed. These asset values are formalized as follows:

\[
(4) \quad E_o(\varepsilon^*, h) = \frac{w_0(\varepsilon^*, h)}{1+r} + \frac{1}{1+r} \int \max[E_r(\varepsilon^*, h), U] dF(\varepsilon^*)
\]

\[
(5) \quad E_r(\varepsilon, h) = \frac{w_1(\varepsilon, h)}{1+r} + \frac{(1-s)}{1+r} E_r(\varepsilon, h)
\]

\[
(6) \quad U = \frac{1}{1+r} \{ (\partial m(\theta)) E_o(\varepsilon^*, h) + (1 - \partial m(\theta)) U \}
\]

Equation (4) is the sum of flow utility of being employed in an entry level job, given by the initial wage \( w_0 \), and the capital gain associated with the option value to be employed in a regular job after that the productivity change at the end of the first stage of employment relationship. In contrast, the worker obtains the lifetime utility of being unemployed if the match is dissolved at the end of the first stage.

Equation (5) is the sum of the flow utility of being employed in a regular job, given by the wage \( w_1 \), and the probability the worker does not retire times the asset value of the utility to remain in a regular job. Similar to the firm, the flow utility of being employed in equations (4) and (5) is discounted by \((1+r)\) because we assume that

\(^{11}\) For what regard the policy parameters, it must be underlined that the economy is characterized by an initial laissez-faire equilibrium in which \( \sigma = T = 0 \). From the first period onward the government may introduced firing tax \( T > 0 \) and hiring subsidies \( \sigma > 0 \), according to the design of the policy
wages are paid at the end of the first stage of the match.

Finally, equation (6) is given by the sum of the hiring transition probability times the asset value of being employed in an entry level job and the probability of remaining unemployed times the expected lifetime utility the currently unemployed. Our model therefore generates a work life cycle in which newly hired workers typically go through a succession of unemployment spells and entry level jobs until they obtain regular jobs, which they keep until they retire (Blanchard and Landier, 2002).

3.3. Wage negotiation and Hold up

In the search equilibrium literature wage determination is typically assumed to be perfectly flexible and determined through a generalized Nash bargaining game (Mortensen and Pissarides, 1994; 1999). Bilateral cooperative bargaining is also assumed in our model, so the initial wage is determined according to the following Nash bargaining rule:

\[
(7) \quad w_o(\varepsilon^e, h) = \arg \max \left[ J_o(\varepsilon^e, h) - V \right]^{1-\beta} \left[ E_o(\varepsilon^e, h) - U \right]^{\beta}
\]

where parameter $\beta$ represents the workers’ bargaining power, assumed constant in both stages of employment relationship. In equation (7), firing taxes do not enter the negotiation as the outsider worker is not eligible by law and firms are not constrained to pay firing costs in case of disagreement during hiring negotiations. Substituting the asset values we derive the equilibrium wage for newly hired workers:

\[
(7') \quad w_o(\varepsilon^e, h) = \beta(\varepsilon^e - h + \sigma) - \beta T + (1 - \beta)rU
\]

When the employer-employee pair negotiates the wage to be paid in the second and later periods of employment, the employment protection policy affects the pairs’ threat points because firing taxes have to be paid by firms if no agreement is reached. The bargaining game in second stage entails:

\[
(8) \quad w_i(\varepsilon, h) = \arg \max \left[ J_i(\varepsilon, h) - V + T \right]^{1-\beta} \left[ E_i(\varepsilon, h) - U \right]^{\beta}
\]

which implies the equilibrium wage for regular workers:

\[
(8') \quad w_i(\varepsilon, h) = \beta(\varepsilon + ah^\omega) + (r + s)\beta T + (r + s)(1 - \beta)U
\]

In the wage schedule (7’)-(8’), the cost of training reduces the initial wage, because it is conditional on agreement to form the match and hence must be shared. But in the second and later periods of the employment relationship, this cost is sunk and does not influence the wage. The firing tax represents an employer liability if the job is destroyed. This means that it causes a higher bargained wage in later periods of

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12 Agreement is always reached so firms never pay the firing taxes which affect wage negotiations, while the firing taxes which are actually paid in equilibrium only affect wages indirectly by affecting the value of matches.
employment, while the effect on the wage paid in the first period is ambiguous -- the
direct effect of the firing tax increases the first period wage, but the increase in training
tends to cause a lower first period wage. Finally, the outside wage increases by a
fraction of the employment subsidy because the payment of the subsidy is conditional
on the worker’s agreement to accept the job offer; in contrast, the insider wage is
independent of the employment subsidy, since the subsidy has already been received.

Equations (7') and (8') highlight an hold up problem in the private provision of
training, even though the perfect wage flexibility assumption for newly hired workers
allows the firms to share a fraction of their training costs with employees. Hold up
arises because the nature of firm specific human capital impedes the firms to commit to
a wage-training contract, i.e. to make a credible commitment to provide training in the
amount agreed with the workers at first stage. Such a commitment cannot be verified
because training activities taking place inside the firms are observable, but not
verifiable. Similarly the match specific shock $\varepsilon$ can’t be verified separately from the
effect of training. If a contract giving the wage as a function of $\varepsilon$ could be written, it
would not be necessary to verify $h$. Since neither $h$ nor $\varepsilon$ can be verified, third parties
can’t tell if productivity is low because a worker was poorly trained or poorly matched.
These properties would make it possible for firms to hire workers at low wages
pretending to offer them training, and then employ them as cheap labour force, if
workers were foolish enough to believe their promises. The firm can always renege on
its training promise even if the worker takes a wage cut to finance his training
(Malcomson, 1999)\textsuperscript{13}.

4. EQUILIBRIUM

In this section we define the equilibrium values of labour market tightness, the job
destruction rate and the level of training with alternative wage setting institutions for
newly hired workers. Then we examine the socially optimal equilibrium and discuss
the relationship between hold up and inefficiency in the decentralized equilibrium.

As it is standard in the matching literature, competition among entrant firms will
make the ex-ante value of a vacancy equal to zero. The firm and worker separate when
the match specific productivity implies a discounted present value of operational
losses higher than the firing tax. The amount of training is chosen by the firm to
maximize its expected discounted profit, after the match is formed and the first period

\textsuperscript{13} Similar conclusions are reached if the firm could write a binding contract about training, but
workers could not take enough of wage cut to finance it. This happens, for example, in presence
of liquidity constraints and/or a binding legal minimum wage. In this case both firing tax and
the cost of training cannot push bargained wage below the minimum level, so that there will be
a lower bound which prevents the firms from sharing these costs with workers.
wage is negotiated.

The equilibrium amount of training and threshold level of productivity below which workers are fired are chosen by the firm to maximize the value of the stream of expected discounted profits resulting from a new match. Define \( e^d \), the threshold value of productivity, the firm’s optimal behaviour implies that:

\[
(11) \quad e^d = (r + s)U - (r + s)T - ah^α
\]

The first term on the right hand side of equation (11) shows that the reservation productivity depends on the opportunity cost of employment. The firing tax causes firms to lower the threshold productivity, and thus to destroy fewer jobs. The returns to training, finally, reduce the threshold value as they increases the overall productivity of the match.\(^{14}\)

Maximizing the expected profits with respect to training, firms choose the investment level such that that expected marginal return equalizes the private marginal cost, then:

\[
(12) \quad h = \left\{ \frac{aα(1 - β)[1 - F(ε^d)]}{(r + s)} \right\}^{\frac{1}{1-α}}
\]

In equation (12) the amount of training depends negatively on the separation rate and the share of labour. This result is driven by the fact that the first period wage is already fixed when the firm chooses the level of training. In contrast the wage paid in later periods increases in training when hold-up implies a reduction of the return to the firm of investment by the factor \((1 - β)\). Contracts can not involve an exchange of first period wages for training, since, once the employee has paid a share of the cost of training through wage bargaining in first stage, the firm has no incentive to maintain the promise to train. Wage renegotiation happens in the second stage, after training is completed.\(^5\)

The job creation equation is derived from the asset value of a vacant job (3) and the value of a new hire to the firm (1) when the free entry condition \( V = 0 \), holds:

\[
(13) \quad \frac{k}{m(θ)} = (1 - β) \left\{ \frac{ε^e - h + σ}{1 + r} - \frac{F(ε^d)T}{1 + r} - \frac{r + (1 - F(ε^d))U}{1 + r} + \frac{1}{(1 + r)(r + s)} \int (ε' + ah^α) dF(ε') \right\}
\]

This equation indicates that the expected cost of posting a vacant job must equalize

\(^{14}\) Equation (11) can be equivalently derived from: \((11') \quad J_1(ε^d, h) = -T\). Since the asset value \(J_1(ε, h)\) increases with the idiosyncratic component \( ε \), there is a unique threshold value. Given labour market equilibrium both (11) and (11') mean that firms and employees decide to separate only if the value of the surplus in the second stage of the match is negative.
the expected profit from a new hire. The left-hand side is the expected cost of a vacancy: it increases with labour market tightness because of matching externalities. The tighter the market, the longer is the expected time to fill a vacancy, and the more costly is posting a vacancy. The right-hand side is the expected profits from employing a newly hired worker.\(^{15}\) Expected profits are decreasing with respect to market tightness, because a tighter labour market increases the exit rate from unemployment and the asset value of being unemployed. Increased training and a lower threshold productivity increase the right hand side of equation (13). That is, firms’ expected profits would be higher if they could pre-commit to a high level of training.

The asset value of being unemployed reduces the right hand side of equation (13) because it exerts an upward wage pressure during bargaining. Its equilibrium value will be:

\[
U = \frac{\theta \beta k}{r(1 - \beta)}
\]

where the positive linear relationship between the value of being unemployed and market tightness is evident. Labour market equilibrium with flexible wages occurs when equations (13) and (14) hold and \(J_\epsilon\) assumes the maximum value for a given value of being unemployed.

**Proposition 1** The first order equations for the maximum expected profit, given by equations (11) and (12), the market tightness equation (13) and the value of being unemployed (14) are necessary and sufficient conditions for an internal local maximum. Thus there exists a unique internal equilibrium for \(\{h, \theta, \epsilon^*, U\}\), if the minimum wage is not binding (see appendix b).

This proposition derives from Kukutani’s fixed point theorem and guarantees that in the labour market there always exists a unique equilibrium associated with a positive separation rate and a positive probability to remain unemployed. A corner equilibrium where no lay-offs occur is conceivable, but it relies on the high values of elasticity of the training function.

### 4.3. Hold up and efficiency

The equilibrium equation (12) derives from the assumption that a firm-worker pair cannot write a completely enforceable and binding contract to determine the division of the increased surplus due to training. Workers and firms, upon meeting, cannot

\(^{15}\) Note that the right hand side of equation (13) is the firms’ share of total surplus evaluated at the first stage of the match: \(J_\epsilon(e^*, h) = (1 - \beta)(J_\epsilon(e^*, h) + E_\epsilon(e^*, h) - U)\)
write a contract that specifies contingent transfers between themselves, and therefore are not able to agree how to share the present discounted value of the total surplus of the partnership.

To evaluate such an inefficiency we calculate the optimal level of training from social point of view, that is the amount of training that would be invested if the employer-employee pair maximizes their joint surplus. Then differentiating the joint surplus of the match, i.e. $S_0 = J_0(e^c, h) + E_0(e^c, h)$, with respect to $h$ yields:

$$h^* = \left[ \frac{\alpha \varepsilon [1 - F(e^d)]}{(r + s)} \right]^{\frac{1}{1-\alpha}}$$

A simple comparison of equation (23) with equation (12) shows the under-investment that characterizes the equilibrium when the workers’ bargaining power is positive, $\beta > 0$. The reason for such an inefficient outcome is that the firm gets only a fraction of the gains of the additional output at second stage due to training, and they do not consider any contribution to the cost of training financed by workers at first stage. When the level of investment is set to maximize the joint surplus the wage rule does not matter, because it only affects the division of the surplus not its magnitude. In the case of a minimum wage which is binding at entry, results are qualitatively unchanged, even though there is less training and job creation in equilibrium.

It is worth noting that inefficiency in the private provision of training is due to hold-up, not to search externalities. From equations (12) market tightness does not affect training, because the optimal amount is chosen after a match is formed and it is possible to revise such a choice. Hold-up causes under-investment and excessive lay-offs irrespective of the relationship between workers’ bargaining share and the properties of the matching function. For this reason, hereafter, we assume that Hosios condition holds, that is $\beta = \eta(\theta)$, where $\eta(\theta) = -\partial m(\theta) / m(\theta)$ is the elasticity of the matching function with respect to unemployment$^{16}$.

### 4.4. An Informal discussion of endogenous retirement

An unusual aspect of our model is our assumption that there is only one match specific productivity shock. In a more standard model, one would assume that both increased training and firing taxes cause a reduced rate of separation of firms and experienced workers. With our notation, this corresponds to a reduction in $s$ as a function of $h$ and $T$. Reduced $s$ and reduced threshold productivity have the effects of the same sign on the first order condition for optimal training. The longer the expected

---

$^{16}$ This approach to design a policy can be justified by arguing that since in general search externalities have an ambiguous impact on welfare and $\beta$ is unobservable, in practice, policy may not succeed in improving this aspect of resource allocation (Pissarides, 2001).
duration of the match, the higher the expected present discounted value of the returns from training. For our purposes, separations reduce the return to training and therefore reduce the profit maximizing level of training. Qualitatively, it doesn’t matter whether or not the separations occur immediately after training.

Some insight into the indirect effects of policy due to endogenous s can be obtained by examining the equilibrium conditions, and considering the effect of a change of s. This examination is not an analysis of equilibrium with endogenous s. With endogenous s, profit maximizing firms would consider the effect of their choice of h on s. For the firms, this is an additional benefit of training, which would appear in the first order condition for the optimal level of training. Nonetheless, the exercise is very simple and potentially of some interest. Note that, other things equal, reduced s causes increased training, a lower threshold productivity and higher asset values including the value of being unemployed. Note also that, in our model, the final effect of the policy on the welfare of the unemployed has the sign one would guess after analysing each variable separately. If firms considered the additional benefit of training due to reduced s, these effects would be stronger but presumably of the same sign.

5. COMPARATIVE STATICS

In this section we analyze the impact of firing taxes and hiring subsidies on labour market outcomes. In particular, we assume that firing costs are an administrative cost (pure waste from a social point of view). Therefore, in this section we set σ equal to zero. In a later section we briefly discuss the more efficient policy in which a firing tax is used to fund a hiring subsidy.

When there are no hiring subsidies, the introduction of a firing tax for newly hired workers always prolongs job tenure and motivates firms to train more. The main difference with respect to an efficient policy design regards the impact on market tightness and, hence, on the welfare of unemployed workers.

The next proposition defines the overall impact of firing cost on the equilibrium value of job creation, job destruction and training:

Proposition 2 - With a flexible wage and no hiring subsidies, the introduction of a firing tax causes higher training, \( \frac{dh}{dT} \bigg|_{T=0} > 0 \), lower job destruction \( \frac{dE^d}{dT} \bigg|_{T=0} < 0 \), while its impact on the market tightness and unemployed value depends on the elasticity of the training function and other parameter values (see appendix c).

Firing costs generate more training and longer job tenure, as in the case of efficient policy with hiring subsidies. Equations (11)-(12) and (18)-(19) react with the expected
signs to the introduction of firing costs, once the match is formed and wage at entry is paid, while the impact on job creation differs in terms of sign and magnitude, whether wage for newly hired is bargained or not.

With flexible wages, the introduction of a small firing tax for newly hired has a positive effect on the welfare of the unemployed, because higher training is associated with higher surplus to be divided, a surplus that firms do not take into account when they maximize profits. On other hand, the higher costs of labour services are not neutralized by hiring subsidies, see equation (13). Thus, the overall impact on the market tightness and the value of being unemployed will depend on the returns to training and on the other parameter values.

With a binding minimum wage, a firing tax always reduces labour market tightness because the wage floor prevents the firms from sharing the higher labour costs. In such a case, the impact on the welfare of unemployed is positive when the gains due to higher expected wage, once the worker is hired, offset the losses due to higher unemployment duration. It is negative otherwise. Again, the labour market outcomes rely on the parametric specification of the model and on the elasticity of the training function.

5.1. A Computational Exercise

In this sub-section we carry out a computational exercise in which the introduction of a small firing tax for newly hired generates a Pareto improving effect in an equilibrium with no hiring subsidies.

Parsimonious functional forms are assumed. Some of the parameters are set at reasonable values while others are chosen to guarantee a computed solution to the model. In particular we assume a log-linear specification of the matching function, \( q(\theta) = A\theta^{-\eta} \), where the scale parameter \( A > 0 \) indicates the efficiency of the matching process and \( \eta \) is the constant elasticity of the matching function with respect to unemployment. The distribution of idiosyncratic productivity is uniform over a finite support \([0, \gamma]\), i.e. \( \varepsilon \sim \text{unif}(0, \gamma) \).

Two labour market policy configurations are then examined. In the first case there is no employment protection and the binding minimum wage is equal to zero. In the second case a small firing tax for newly hired is introduced while minimum wage does not change.

The initial values of endogenous variables and the baseline parameters are reported in Table 1, where the time period is a year. The policy parameters, \( w \) and \( T \), are initially set equal to zero. The real interest rate, \( r \), and the probability of exogenous separation, \( s \), are both set equal to 0.04. The search externalities are ruled out by imposing the Hosios condition \( \beta = \eta \) and the workers’ bargaining power is fixed to 0.5.
With regard to the endogenous variables, the initial value of being unemployed is fixed considering an economy without training and a market tightness equal to 0.4. The initial amount of training and threshold productivity are determined by equations (18) and (19) when the upper bound of the idiosyncratic productivity distribution $\gamma$ is chosen so that separation rate at the first stage of the match $\varepsilon^d_\gamma$ is equal to 0.25.

The value of being unemployed and average productivity for newly hired workers implies, in turn, a parametric restriction on the efficiency of the matching technology, the parameter $A$, and on the parameter $a$ of the training function, $f(h) = ah^\alpha$. Similarly the recruitment cost of posting a vacancy, $k$, is determined endogenously by the value of a filled job and the exit rate from unemployment, taken to be equal to 0.3. Finally, the critical value of parameter $\alpha$ is set equal to 0.55 to guarantee that the interior local maximum is the global maximum so that the analysis will concern an equilibrium where $\varepsilon^d > 0$ and $h < h_{\text{max}}$.

In the search environment described above, we consider the introduction of a small firing tax equal to $T=0.00001$, while the minimum wage is fixed to zero. The impact of such a policy is measured by the variation of the amount of training, the variation of the separation rate and of the market tightness. In particular the value of being unemployed represents the target variable to evaluate the welfare improving effect of the firing tax. The results of our exercise are displayed in Table 2 where it is shown that such a policy may have positive effects both for the welfare of unemployed and employed.

In our numerical example the increase of the welfare of the employed is driven by the increase of job tenure and training, while the decline of the market tightness does not hurt employees because of envelope property. The increase of the value of being unemployed, instead, is due to the fact that the productivity of trained employees is high enough to offset the negative impact of the firing tax on unemployment duration. In this case the firing taxes favour the creation of “good” jobs in terms of high wages, job stability and skills accumulation so that the unemployed workers trade-off longer unemployment duration with better jobs once hired.

6. THE EFFECTS OF POLICY WITH A HIRING SUBSIDY ($\sigma > 0$)

The aim of hiring subsidies, given to firms which hire workers, is to offset the direct costs of firing taxes. The public sector satisfies the inter-temporal budget constraint with equality, so that the amount of job subsidies is determined by the revenues from firing taxes. Note that the first subsidies are paid one period before the first firing taxes are collected, since firms are not taxed for firing workers who were employed when the policy is introduced. This means that the inter-temporal budget constraint
requires that the subsidy for hiring a given worker is equal to the expected present value of firing taxes collected due to the firing of that worker so

\[ \sigma = \frac{F(\bar{\varepsilon})T}{(1 + r)} \]

Equation (24) specifies that the amount of the subsidy depends on the average threshold level of productivity, in a symmetric equilibrium where all firms optimally choose the same separation rate, \( \bar{\varepsilon} = \varepsilon^d \). Thus the amount \( \sigma \) is given to the firms which hire workers. Under these hypotheses, the welfare of unemployed workers always increases if a small firing tax is introduced in a \textit{laisser-faire} economy. In particular the following proposition holds when the minimum wage is not binding:

**Proposition 3** With hiring subsidies, the introduction of a small firing penalty increases training investment, \( \frac{dh}{dT} \bigg|_{T=0} > 0 \), and job creation, \( \frac{d\theta}{dT} \bigg|_{T=0} > 0 \), while it decreases job destruction, \( \frac{d\varepsilon^d}{dT} \bigg|_{T=0} < 0 \). Thus, a small positive firing penalty causes increased employment, productivity and welfare of unemployed workers (see appendix d).

The introduction of firing taxes prolongs the expected duration of a match, during which the returns to training are realized. This increases the present value of the employment relationship and leads to more training, higher productivity and, hence, higher welfare of the employed.

Further, a rise of \( T \) increases the expected cost of labour services by augmenting the direct cost at separation and, indirectly, causes increased bargained wages by improving workers’ threat point. These negative effects on firms’ expected profit discourage job creation and hurt the welfare of unemployed.

However, the direct negative effect of \( T \) on firms’ profit is neutralized by hiring subsidies, while its impact on the wages of trained workers is offset by a reduction in the wage of newly hired workers. The firing taxes have a first order effect on welfare because the social returns to training are higher than the private returns, even though the firms do not consider the social gains associated to their choice. That is, the envelope property does not hold when \( T \) is introduced and increased training has positive net social benefits proportional to \( \beta \).

**7. THE EFFECT OF A BINDING MINIMUM WAGE**
In this section we consider a binding minimum wage which is higher than the wage to which firms and workers would negotiate for the first period of employment relationship. Formally, if we denote the wage at first stage as \( w_{e,h} = \text{Max}\{w_{h}, w\} \), a binding minimum wage hypothesis would imply \( w_{R} > w \), where subscript \( R \) denotes a rigid wage regime.

A binding minimum wage makes it impossible for workers to share the costs of training even if \( h \) and \( e \) are verifiable. Then the existence of a binding minimum wage is an alternative possible cause of holdup and the resulting inefficiency. In this case labour market regulations imply a fixed initial wage which can be renegotiated in the second stage by mutual agreement\(^{17}\).

The labour market equilibrium when minimum wage is binding for newly hired workers shows the same qualitative features as the equilibrium in the perfect flexible case. We use the subscript \( R \) to indicate that we are considering equilibrium with a rigid initial wage due to the binding minimum wage.

The optimal training investment and threshold productivity, again, are determined to maximize firms’ expected profits, for each given value of workers’ outside option:

\[
(18) \quad \varepsilon^d = (r+s)(U_h - T) - ah^a
\]

\[
(19) \quad h = \frac{a(1-\beta)[1-F(\varepsilon^d)]}{(r+s)}
\]

Equations (18) (19) have the same characteristics as their flexible wage counterparts because firms unilaterally determine the amount of training and separation rate taking the wage paid in the first stage as given, whether it is flexible or rigid\(^{18}\). The equation describing equilibrium market tightness is:

\[
(20) \quad \frac{m(\theta)}{m(\theta)} = \left\{ \frac{\varepsilon - w_h - h}{1+r} - \frac{[\beta + (1-\beta)F(\varepsilon^d)]T}{1+r} - \frac{(1-\beta)[1-F(\varepsilon^d)]U_{h_{R}}}{1+r} + \frac{(1-\beta)}{(1+r)(r+s)} \varepsilon h^a dF(\varepsilon) \right\}
\]

\(^{17}\) Cauch et al. (2001) also introduces a fixed wage that can be renegotiated by mutual agreement only to yield plausible wage profile. This assumption is worthy for empirical and theoretical reasons. First, it appears to be an important feature of labour contracts in Continental Europe (Malcomson, 1997; Garibaldi and Violante, 2005). Second, it can justified by non-cooperative game theory in an environment where the idiosyncratic components of a job are not verifiable (MacLeod and Malcomson, 1993). Indeed, if the information is unverifiable, many contract provisions may be unenforceable because a court does not have the information necessary to enforce them. In this context a contract that specifies a fixed wage is easy to enforce. Hashimoto and Yu (1981) discuss the importance of such contracts in reducing hold up problems related to investment in firm specific human capital.

\(^{18}\) The second order condition on the Hessian matrix is also invariant to wage setting institution.
In equation (20), again, increased market tightness increases the expected cost of filling a vacancy while it decreases the firm expected profits from a new hire. On the other hand, one key implication of limiting the extent of downward wage flexibility of newly hired workers is that firms cannot make newly hired workers pay their share of expected future firing taxes through a lower initial wage. This implies that market tightness is decreasing in the firing tax. Also for any given firing tax fewer jobs are created and labour market tightness is reduced.

Under wage rigidity, the equilibrium value of being unemployed is not a linear function of market tightness:

\[
U_R = \frac{\theta_R m(\theta_R) \left\{ w_R + [1 - F(\varepsilon^d)] \beta T + \frac{\beta}{(r + s)} \int_{\varepsilon_2}^{\varepsilon_1} (\varepsilon' + a h^a_\eta) dF(\varepsilon') \right\}}{r(1 + r) + \theta_R m(\theta_R) \psi + \beta [1 - F(\varepsilon^d)]}
\]

Equation (21) shows a positive non linear relationship between the value of being unemployed, the market tightness and job tenure. The equilibrium with rigid wage for newly hired workers will occur when equations (20) and (21) hold and \( J_0 \) assumes the maximum value for a given value of being unemployed.

Proposition 4 Equations (18)-(19)-(20) and (21) are necessary and sufficient conditions for an internal local maximum. Then, there exists an unique internal equilibrium for \( \{h_R, \theta_R, \varepsilon^d, U_R\} \) if the minimum wage is binding. (appendix e)

The rigid wage equilibrium has the same qualitative characteristics as the flexible wage equilibrium because the firm’s optimal behaviour is not affected by sharing rule prevailing at first stage of the employment relationship. Expected profits are maximized with respect to training choice and job destruction rate once the match is formed and first period wage has been paid.

The analysis of the comparative statics can be extended to an equilibrium in which minimum wage is binding for newly hired workers. In such a case it will be:

Proposition 5 With employment subsidies and a rigid initial wage, the introduction of a

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19 In the appendix we show that equation (21) can be equivalently expressed as the as sum of the outside options of the match. In such a way it becomes evident that wage setting institutions determine how the surplus is shared, but not its total amount.
firing tax increases training investment, \( \frac{dh_t}{dT} \bigg|_{T=0} > 0 \), while decreases job destruction \( \frac{de_{w_t}}{dT} \bigg|_{T=0} < 0 \) and job creation \( \frac{d\theta_{e_t}}{dT} \bigg|_{T=0} < 0 \). A positive firing tax, also, increases the welfare of unemployed workers if 

\[
(w_h - w_f) < -\frac{k^2(1-\beta)[1-F(e^*_w)] + \sqrt{k^2(1-\beta)[1-F(e^*_w)]^2 + 4\varepsilon J_0 \cdot k^2 \cdot (1-\beta)[1-F(e^*_w)]}}{2 \cdot [r \cdot J_0 \cdot k^2 \cdot (1+r)\eta \cdot \theta_{e_t} m(\theta_{e_t})]}.
\]

(see appendix e)

With entry wage rigidity, the welfare of employed workers increases with firing taxes for newly hired because it increases both job tenure and training, while unemployed workers gain from firing taxes only if the minimum wage is not too much higher than the wage which would have been negotiated. Even though market tightness is lower and unemployment duration increases, the expected income of the unemployed increases because, once a job is found, workers obtain higher wage and longer tenure. This result is driven by the envelope property that characterizes firm’s optimal behaviour and by the fact that hiring subsidies neutralize the direct impact of firing taxes on expected profits.

8. UTILITARIAN SOCIAL WELFARE ANALYSIS

Welfare analysis can be extended to consider the introduction of a firing tax for newly hired workers when there are three categories of individuals in the initial steady state: unemployed, newly hired workers and insider workers.

Utilitarian social welfare is the sum of utilities of workers and firms at a given period of time, denoted with the subscript \( t \). By definition:

\[
(25) \quad S(h, T) = u(W + U) + m(u, v)[J_0(\varepsilon, h) + E_0(\varepsilon, h)] + (1 - u - m(u, v))[J_1(\varepsilon, h) + E_1(\varepsilon, h)]
\]

where the first term on the right side of equation (25) is the expected income associated with vacant job and unemployment status and the second and the third terms are the joint surplus of a filled job formed at time \( t-1 \) and \( t-2 \), respectively. Given the equilibrium values of asset equations and the free entry condition, \( V=0 \), we

\footnote{The orthodox human capital theory predicts that minimum wage is associated with less specific training sponsored by firms (Neumark and Watcher, 1999). Proposition 4 is coherent to this outcome as rigid wage binding at entry impedes the firms to share the investment cost. On the other hand, when employment protection is concerned, our analysis mitigates the traditional results of the standard theory.}
can rewrite the social surplus as follows, \( \forall i = R, f : \)

\[
S_i(h) = uU + \frac{m(u, v)}{1 + r} \left[ \varepsilon^i - h - F(\varepsilon^i)T + \left[ 1 - F(\varepsilon^i) \right] U^i + \frac{1}{(r + s)} \left( \varepsilon^i + ah^i \right) dF(\varepsilon^i) \right] + \frac{1 - u - m(u, v))}{(r + s)} [\varepsilon + ah^i]
\]

The time structure of the employment relationship shows that the joint surplus at \( t - 1 \) can be affected by firing taxes introduced at time \( t \), while for matches formed in \( t - 2 \), the optimal choices cannot be reversed by current policy intervention and only the returns to past investment are available. Then, we have two cases: 21

**Case A:** The economy is populated only by unemployed workers, and the social welfare is identified by the equilibrium value of being unemployed \( S_i(h) = uU \), with \( i = R, f \). Thus the impact of firing costs will depend generally on the efficient design of economic policy, wage institutions and returns to training. In absence of hiring subsidies, the impact of firing tax for newly hired relies on the degree of the concavity of training function, that is there will be a range of parameter values \( \alpha, 0 < \alpha < 1 \), such that \( \frac{dS_i(h, T)}{dT} > 0 \).

**Case B:** The economy is populated by unemployed, newly hired workers and regular workers, see equation (26). Given that the introduction of firing taxes favours job durations and training investment, the firing tax increases the joint surplus of a filled job at time \( t - 1 \), leaving unaffected the optimal choices made at \( t - 2 \), so that the overall impact on welfare will be higher than in Case A, either with hiring subsidies or without them.

### 9. CONCLUDING REMARKS

This paper shows that inefficiency induced by hold up in the private provision of training can justify the introduction of positive amount of firing tax in economies populated by risk neutral or perfectly insured agents. Two main results are illustrated. First, an efficient economic policy, which makes use of a combination of a small firing taxes for newly hired and hiring subsidies, always increases employment, productivity and welfare. Second, there is not a clear relationship between firing taxes and welfare when there are no hiring subsidies. The effect depends on the returns to training and on the parametric specification of the model. In particular, if the returns to training are

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21 The equation (26) is subject to a dynamic of unemployment in each period of time (27) \( u_t = u_{t-1} - m(u_{t-1}, v_{t-1}) + F(\varepsilon^i_t) \). In steady state it will be: \( m(u, v) = F(\varepsilon^i) \)
not high enough, the introduction of firing taxes for newly hired may be associated with lower market tightness even though it always increases job durations and training. This highlights a case in which the firing taxes imply a trade off between adjustment costs and productivity gains. Implications of wage rigidity for newly hired workers where firms cannot share the costs with employees are also considered.
References


Appendix A: The local maximum

Firms maximize their expected profit with respect to training and threshold productivity, i.e. \( \max J_0(\varepsilon^d, h) \). The equilibrium wage at entry does not vary when firms make their optimal choices, so that the expected profit is

\[
J_0(\varepsilon^d, h) = \frac{\varepsilon^d - h - w_{0,\alpha} + \sigma}{1 + r} - \frac{[F(\varepsilon^d) - \beta(1 - F(\varepsilon^d))] \cdot T}{1 + r} - \frac{(1 - \beta)[1 - F(\varepsilon^d)] \cdot U}{1 + r} + \frac{(1 - \beta)}{(r + s)(1 + r)} \int (\varepsilon^d + ah_i) dF(\varepsilon^d)
\]

where \( i = f, R \). First order conditions are given by equations (11) and (12) or equations (18) and (19). To find a local maximum the Hessian matrix must be semi definite negative so that:

\[
(1 - \beta)^2 a(1 - \alpha) h_{i}^{\alpha - 2} [1 - F(\varepsilon^d)] f'(\varepsilon^d) [1 - F(\varepsilon^d)] - (1 - \beta) [f'(\varepsilon^d)]^2 \sigma^2 a^2 h_i^{2\alpha - 2} \frac{(r + s)^2 (1 + r)^2}{(r + s)^2 (1 + r)^2} > 0 \quad i = f, R
\]

that is:

\[
\frac{(1 - \alpha) \cdot [1 - F(\varepsilon^d)]}{a \cdot \alpha \cdot f'(\varepsilon^d)} > h_i^\alpha \quad i = f, R
\]

The second order condition for a local maximum is formally the same in flexible wage and in rigid wage equilibrium.

Appendix B: Existence and Uniqueness Of Equilibrium\(^{22}\)

1.b) Existence. Define the four component vector \( z = (h_{f}, \varepsilon^d_{f}, \theta_{f}, U_{f}) \). An equilibrium is a fixed point of the correspondence \( \Psi \) from \( z \) to \( z \), with \( \Psi(z) = (h_{f}(z), \varepsilon^d_{f}(z), \theta_{f}(z), U_{f}(z)) \), where \( \theta_{f}(z) \) is defined implicitly by equation (13), \( U_{f}(z) \) is defined by equation (14) and \( h_{f}(z) \) and \( \varepsilon^d_{f}(z) \) are chosen to maximize \( J_{f, 0}(\varepsilon^d, h) \). The correspondence \( \Psi \) is a best response relation. Thus it is convex valued and has a closed graph. \( \Psi \) maps a convex compact set into itself, so Kukutani’s fixed point theorem implies that \( \Psi \) has a fixed point, which is an equilibrium.

\(^{22}\) At sake of notational simplicity, in the proofs we omit the subscripts indicating flexible wage equilibrium.
Proof. To prove the continuity of functions in vector \( z \) is straightforward. The optimal training choice is a continuous function and takes values in the range \( 0 \leq h \leq \left[ a(1-\beta) \right] \frac{1}{r+s} = \bar{h} \); then the set of possible values of training is compact. Market tightness is also continuous and assumes values in the range:

\[
0 \leq m^{-1}(\theta) < \left[ \frac{(1-\beta)e^\epsilon}{k(1+r)} + \frac{(1-\beta)(e + ah^e)}{k(1+r)(r+s)} \right].
\]

The value of being unemployed can be written as

\[
U = \left( h, \theta, \frac{r(1-\beta)}{f(k)} U \right), \quad \text{with} \quad \theta = \frac{r(1-\beta)}{f(k)} U,
\]

so that \( 0 < U \leq U(\bar{h}, \epsilon_U) = \bar{U} \). Finally \( \epsilon = \epsilon(0, \bar{h}) < \epsilon' < \epsilon(\bar{U}, 0) = \bar{\epsilon} \), where \( [\epsilon_L, \epsilon_U] \) is the finite support of the distribution of the idiosyncratic productivity and \( h_{\text{max}} \) is the maximum amount of training.

2.b) Uniqueness of the interior solution. If condition (ii) is met, the maximized expected profit can be represented as function of the equilibrium value of being unemployed: \( J_0(U) = \max_{\epsilon, h} J_0(\epsilon, U), h(U), U \). \( J_0(U) \) is continuous and decreasing with respect to the value of being unemployed, \( \frac{dJ_0}{dU} < 0 \), so that \( \frac{d\theta(J_0)}{dU} < 0 \). Considering the positive monotonic relation between the equilibrium market tightness and workers’ outside option \( \epsilon \), equation (14), and the continuous positive relation between \( \theta \) and \( J_0(U) \), equation (13), it is verified that:

\[
\frac{dU(J_0, \theta(J_0))}{dU} < 0.
\]

Thus there can be only one equilibrium value of \( U \) and, as a consequence, there is only an equilibrium value of \( \theta \). Two different solutions to \( (h, \epsilon') \) would have to give the same maximal \( J_0(\epsilon', h) \) and the same \( U \). However this result is not possible since the sum \( J_0 + E_0 \) is increasing in \( h \) at the equilibrium.

3.b) A corner solution. A corner equilibrium with no layoffs is also possible for some parameters. When \( \epsilon'_f = \epsilon_L \), the equilibrium values of training and market tightness are given by equations (12)-(13):

\[
\begin{align*}
h_{\text{max}} &= \left[ a(1-\beta) \right] \frac{1}{r+s} \\
m^{-1}(\theta) &= \left( \frac{1-\beta}{k(1+r)} \right) \left[ (e^\epsilon - h_{\text{max}}) - rU + (e^\epsilon + ah^e) \right]
\end{align*}
\]

while the value of being unemployed is determined by equation (14). We note that in equation (14), for \( \theta = 0, \ U = 0 \), and for \( \theta \to +\infty, \ U = U_{\text{max}} \). In equation (13) for \( U = 0, \ \theta > 0 \), and for \( U > 0 \), \( \frac{\partial \theta}{\partial U} < 0 \). This implies a decreasing relationship between
job creation condition and workers’ outside option when $\varepsilon^d = \varepsilon^*_z$ and $h_f = h_{\text{max}}$. Thus, there exists a candidate equilibrium $\{\varepsilon^*_z, h_{\text{max}}, \theta, U\}$.

**Appendix C: Comparative Statics For the Baseline Model**

With no hiring subsidies, the introduction of firing costs implies on job creation condition:

$$\frac{d\theta}{dT} = \frac{(1-\beta)}{\Theta(1+r)} \left[ \beta \frac{dh}{dT} - F(\varepsilon^d) \right]$$

Following the same procedure as in the case of efficient policy, we have:

$$\frac{d\varepsilon^d}{dT} = \left[ -(r+s) \left( \frac{\Theta \cdot r(1+r) + (r+s) f k (\varepsilon^d) \cdot r(1+r) f k (\varepsilon^d)}{\Theta \cdot r(1+r) f k (\varepsilon^d)} \right) - \frac{f(\varepsilon^d) a^2 \alpha^2 (1-\beta)^a}{(1-\alpha)(r+s)} + (r+s) \frac{\beta^2 k}{\Theta \cdot r(1+r)} f(\varepsilon^d) a \alpha (1-\beta)^a }{(1-\alpha)(r+s)} \right] < 0$$

and

$$\frac{dh}{dT} = \frac{f(\varepsilon^d)}{(1-\alpha) (1-F(\varepsilon^d))} \frac{d\varepsilon^d}{dT} > 0$$

The Sign of the effect on market tightness is no clear a priori.

**Appendix D: Comparative Statics with Hiring Subsidies**

Differentiating totally equations (11) (12) (13), once substituted equilibrium budget constraint, $\sigma = F(\varepsilon^d)T$ , one obtains:

$$\frac{d\theta}{dT} = \frac{1}{\Theta(1+r)} \left[ \beta \frac{dh}{dT} + \frac{(1-\beta)}{(1+r)} \left( F(\varepsilon^d) - F(\varepsilon^d) \right) + \frac{(1-\beta) f(\varepsilon^d) T}{(1+r)} \right]$$

where: $\Theta = \frac{\eta \cdot \theta}{m(\theta)} + \frac{r + [1-F(\varepsilon^d)]}{1+r} \cdot \frac{\beta k}{r(1-\beta)}$. Given that $\varepsilon^d = \varepsilon^d$ and evaluating job creation at $T=0$, it reduces to:

$$\left. \frac{d\theta}{dT} \right|_{T=0} = \frac{1}{\Theta(1+r)} \beta \frac{dh}{dT} \left. \right|_{T=0}$$. From equation (14) we have

$$\frac{dU}{dT} = \frac{\beta^2 k}{\Theta \cdot r(1+r)} \frac{dh}{dT}$$

so that, on the job destruction condition, will be:
\[
\frac{d\epsilon^d}{dT}\bigg|_{r=0} = \left\{ -\frac{(r + s)}{k} \right\} < 0
\]

Training is inversely related to the threshold productivity, when firing cost varies, i.e.
\[
\frac{dh}{dT}\bigg|_{r=0} = -\frac{f(\epsilon^d)}{(1-\alpha)[1-F(\epsilon^d)]^{n-2}} \frac{d\epsilon^d}{dT} > 0 \quad \text{and, as a consequence,} \quad \frac{d\theta}{dT}\bigg|_{r=0} > 0 \quad \text{and} \quad \frac{dU}{dT}\bigg|_{r=0} > 0.
\]

**Appendix E: Existence, Uniqueness and comparative statics with a rigid wage**

**i) Existence and Uniqueness**

Given a four component vector \( z = (h_r, \epsilon^d, \theta_r, U_r) \) a fixed point of the correspondence \( \Psi \) from \( z \) to \( z \), with \( \Psi(z) = (\bar{h}_r(z), \epsilon^d_r(z), \theta_r(z), U_r(z)) \) is defined as in the proof 1.b) with respect to equations (18)-(19)-(20) and (21). Moreover the set of possible values of training investment is compact, and market tightness assumes values in the range:
\[
0 < m^{-1}(\theta) < \left[ \frac{\epsilon^d}{k} + \frac{(1-\beta)(\epsilon^d + ah^\alpha)}{(1+\alpha)(r+s)} \right].
\]
The value of being unemployed is also bounded, i.e.:
\[
0 < U \leq \frac{\epsilon^d + ah^\alpha}{r(1+r)}.
\]
Consequently \( 0 < U \leq U(\bar{h}, \epsilon^d) = \bar{U} \). and as in the flexible case \( \bar{\epsilon} = \epsilon(0, \bar{h}) < \epsilon^d < \epsilon(U, 0) = \bar{\epsilon} \). The proof of uniqueness is almost identical to the proof in the case of flexible wages.

**ii) Comparative Statics**

Differentiating equation (20) with respect to \( T \) yields:
\[
\frac{\eta \cdot \theta}{m(\theta)} \frac{d\theta}{dT} - \frac{\beta}{1+r} \frac{dh}{dT} \frac{(1-\beta)[1-F(\epsilon^d_r)]}{1+r} \frac{dU}{dT}.
\]

To simplify the algebra, equation (21) can be equivalently expressed as sum of the outside options:
(iii) \( r(U + \theta \cdot \bar{V}) = -k\theta \cdot m(\theta)(J_0 + E_0 - U) \).

that is, as the sum of the cost of search, proportional to the market tightness, and the

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23 Again, we omit the subscripts indicating rigid wage equilibrium in the proofs.
social surplus of the match. Now, differentiating equation (iii) with respect to $T$:

$$(iv) \quad \frac{d(U + \Theta V)}{dT} = \frac{dU}{dT} + \frac{d(U + \Theta V)}{dT} = \frac{\partial m(\theta)}{\partial h} \cdot \frac{dh}{dT} + \frac{\partial (U + \Theta V)}{dT} \cdot \frac{d\varepsilon^d}{dT} + \frac{\partial (U + \Theta V)}{dT} \cdot \frac{d\theta}{dT}$$

where $\frac{\partial (U + \Theta V)}{\partial h} = \frac{\partial m(\theta)}{\partial h} \cdot \frac{dh}{dT}$ and $\frac{\partial (U + \Theta V)}{\partial \theta} = 0$, because of $\sigma > 0$. Moreover, $\frac{\partial (U + \Theta V)}{\partial \theta} = \frac{k}{r \cdot J_0} \left[(\beta - \eta)(J_0 + E_o - U)\right]$. With rigid wage hypothesis this is equivalent to $\frac{\partial (U + \Theta V)}{\partial \theta} = \frac{k}{r \cdot J_0} [\beta - \eta](J_0 + E_o - U) + w_g - w_f$.

As the Hosios condition holds, $\beta = \eta$, it results: $\frac{\partial (U + \Theta V)}{\partial \theta} = \frac{k}{r \cdot J_0} (w_g - w_f) \geq 0$.

Inserting this expression into equation (iv):

$$(v) \quad \frac{d(U + \Theta V)}{dT} = \frac{dU}{dT} + \frac{\partial m(\theta)}{\partial h} \cdot \frac{dh}{dT} + \frac{k}{r \cdot J_0} (w_g - w_f) \cdot \frac{d\theta}{dT}$$

The relationship between training investment and labour market tightness can be written as: (vi) $\frac{d\theta}{dT} = -\frac{\partial m(\theta)(1 - \beta)[1 - F(\varepsilon^d)]}{\Xi \cdot r \cdot (1 + r)^2} \cdot \frac{dh}{dT}$, where

$$\Xi = \frac{r \cdot J_0 \cdot (1 + r) \cdot k \cdot \eta \cdot \partial m(\theta) + k \cdot (1 - \beta)[1 - F(\varepsilon^d)](w_g - w_f)}{r \cdot J_0 \cdot (1 + r)}$$. The effect of firing tax on the job destruction equation is:

$$\frac{de^d}{dT} \bigg|_{\tau = 0} = \frac{-\tau}{(1 - \alpha)(1 - F(\varepsilon^d))} \cdot \frac{de^d}{dT}$$

so that from equation (vi) and $\frac{dh}{dT} \bigg|_{\tau = 0} = -\frac{f(\varepsilon^d)}{(1 - \alpha)(1 - F(\varepsilon^d))} \cdot \frac{de^d}{dT}$ we have:

$$\frac{de^d}{dT} \bigg|_{\tau = 0} = \frac{-\tau}{(1 - \alpha)(1 - F(\varepsilon^d))} \cdot \frac{de^d}{dT}$$

with $\Phi = 1 - \frac{f(\varepsilon^d) a \cdot \alpha^2 (1 - \beta) h^{2\alpha - 1}}{(1 - \alpha)(1 + r)} + \frac{(r + s) \cdot \partial m(\theta)}{(1 + r) \cdot (1 - \alpha)(1 - F(\varepsilon^d))} \cdot \beta \cdot \frac{f(\varepsilon^d) a \cdot \alpha (1 - \beta) h^\alpha}{(1 - \alpha)(1 + r)} > 0$. Then it will be $\frac{dh}{dT} \bigg|_{\tau = 0} > 0$ and $\frac{d\theta}{dT} \bigg|_{\tau = 0} < 0$. Finally, form equation (iv) $\frac{dU}{dT} \bigg|_{\tau = 0} > 0$ if and only if
$$w_R - w_f < - rac{r J_0}{k} \frac{d \theta}{dT} \frac{d \theta}{ \partial m(\theta) \beta} \frac{dh}{dT}.$$ Once substituted the correspondent value $\frac{d \theta}{dT}$ and $\frac{dh}{dT}$, the welfare of unemployed increases if and only if $w_R - w_f < \frac{r J_0 (1 - \beta) (1 - F(\varepsilon^d))}{k \cdot \Xi \cdot r (1 + r)}$. The latter is a second order equation in $(w_R - w_f)$ so that, taking its positive solution, one yields:

$$w_R - w_f = \frac{- k^2 (1 - \beta) (1 - F(\varepsilon^d)) + \sqrt{[k^2 (1 - \beta) (1 - F(\varepsilon^d))]^2 + 4 \cdot r \cdot J_0 \cdot k^2 \cdot (1 - \beta) (1 - F(\varepsilon^d))}}{2 \cdot [r \cdot J_0 \cdot k^2 \cdot (1 + r) \eta \cdot \partial m(\theta)]}.$$
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