Employment Protection Legislation and Adverse Selection at the Labor Market Entry

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Abstract

This paper investigates how the labor market institutions that characterize most of the European countries affect the integration process of younger workers on the labor market. We argue that young workers have private information about their abilities when entering the labor market. However, this information asymmetry does not prevail as the production process reveals the worker's type. Adverse selection distorts hiring practices at the labor market entry. We develop a dynamic principal-agent model and first derive the optimal menu of labor contracts employers can use as a self-selection mechanism. Firms offer an increasing wage to high-productive workers while a flatter wage profile to low-productive workers. Our theory suggests that a high level of firing costs as well as the presence of a minimum wage prevent employers from offering separating contracts to new entrants and thus contribute to the time-consuming integration process of youth. Finally, we provide numerical exercises to illustrate our theoretical findings on the optimal wage profile and to assess the consequences for employment opportunities.

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1   Introduction

One of the assumptions that drives efficiency of competitive labor markets is that firms and workers have perfect information about the quality of a match, firm's or worker's productivity. In reality, labor markets operate in an environment where there is incomplete information. Economists have concerned themselves with the optimal employment contract under incomplete information since the seminal papers of (Lazear E.P. 1981) and (Shapiro C. and Stiglitz J.E. 1984). The optimal wage dynamics concern arose as the empirical evidence has suggested for many years that the wage increases with job tenure for a given productivity. The theoretical analysis of (Salop J. and Salop S. 1976) had already provided some explanations. The authors suggested that firms discourage individuals characterized by a high propensity to quit the job by increasing the wage with job tenure. (Harris M. and Holmstrom B. 1982) argued that the optimal wage profile is increasing as both firms and workers gradually learn about workers' ability by observing the output produced over time. The authors considered incomplete but symmetric information about workers' abilities. One can argue that adverse selection may arise in the labor market when workers have private information about their productivity, trainability or preferences. Hiring a worker can be risky as less desirable workers have an incentive to overstate their qualifications. Firms are thus induced to design a screening device to reveal the worker's type. There is no empirical evidence suggesting that firms do not implement self-selection mechanisms as separating employment contracts to induce the worker to reveal his type by his behavior. Recently, (Guerrieri V., Shimer R. and Wright R. 2009) extended the competitive search equilibrium model of (Moen E.R 1997) to environments with adverse selection. They show that equilibrium exists where firms offer separating contracts to which different types of workers direct their search. Pooling contracts will not increase firms' profit.

This paper supports the idea that labor markets operate in an environment where adverse selection appears mainly at the labor market entry, thus making the hiring of new entrants risky. We propose a dynamic principal-agent model to derive the optimal menu of separating labor contracts firms implement to induce self-selection from workers of different abilities. Our main contribution is then to analyze how the labor market institutions that characterized most of the European countries, namely high firing costs and minimum wage, affect the optimal wage profile or prevent firms from implementing a menu of separating contracts. Besides, we rely on a standard matching model *à la* Pissarides to analyze the consequences on job creation decisions and employment at the labor market entry. The analysis we perform suggests that both adverse selection and labor market institutions contribute to the time-consuming integration process of youth on the labor market.

Young workers entering the labor market have usually either never worked or had few contacts with employers. While the new entrants may know their own level of ability, the hiring firms could not be able to perfectly observe it before engaging in production. The signaling theory ((Spence M. 1973)) argues that education can be used as a signal of high levels of abilities to the firm thereby narrowing

the informational gap. But workers may still be unequally productive in employment within the same qualification level. However, the asymmetry of information should not prevail on the labor market. Typically, firms infer the ability of their workers by observing the output they produce. (Farber H. and Gibbons R. 1996) use longitudinal data and find that the influence of abilities on wages increases with workers' experience thus providing empirical evidence on employers learning. But most of the empirical studies ((Schoenberg U. 2007), (Schweri J. and Mueller B. 2008)) conclude that employer learning is symmetric. The worker's employment experience, as the unemployment history should indicate a certain level of productivity. For instance, long-term unemployment is usually associated with a loss of human capital thus leading to stigmatization of job seekers and to discrimination from employers. This paper assumes accordingly that firms do not have superior information regarding its employees'abilities relative to other firms: they learn both about the abilities of their own employees and about that of the other workers. We thus distinguish new entrants who have private information about their abilities and experienced workers who has been previously revealed in employment.

Our first contribution is to analyze the optimal wage dynamics under adverse selection at the labor market entry. While offering a constant wage is an optimal decision under full information, we show that firms offer an increasing wage to high-productive workers but a flatter wage profile to low-productive workers. The wage is usually downward rigid, but firms have the possibility to fire the workers who did not choose the contract designed for them. Bad workers are not induced to shirk as they will be dismissed before gaining access to the highest wage level offered to good workers. One should notice that (Hagedorn M., Kaul A. and Mennel T. 2002) found similar results when deriving the optimal unemployment benefits profile under adverse selection: decreasing benefits are designed to good searchers while the optimal profile designed for bad searchers is flatter.

Further, we propose to analyze the interactions between discrimination and Employment Protection Legislation (EPL). By EPL, we refer to regulations concerning firing costs. The reduction of firing costs has often been advocated by economists to favor hirings of young workers. (Pries M. and Rogerson R. 2005) developed a learning model in which firms and workers have incomplete information about match's quality. They argued that firing costs induce firms to be more selective in whom they hire and prevent them from sorting bad matches. High level of EPL should affect self-selection mechanisms in an environment where adverse selection operates by preventing the firm from dismissing shirkers.

Our analysis is performed in two stages. First, to derive analytical results we investigate the optimal menu of contracts under the assumption that the wage is constant over time. We show that in the absence of any firing costs, the firm is able to implement a menu of separating contracts that gives to low-productive workers an information rent, as standard in the theory of incentives. The EPL does not affect the labor contract until a threshold value. Then, for intermediate values of firing costs, the previous contract no longer allows firms to dismiss bad workers who did not choose the contract designed for them. However, a menu of separating contracts can still be implemented. The firm faces

a trade-off between increasing the wage designed for good workers in order to allow for the dismissal of bad mismatched workers and thus to implement a menu of contracts, or implementing a pooling contract that gives bad workers a higher information rent. Finally, for the highest levels of EPL, firms are unable to design a self-selection mechanism which strongly reduces the employment opportunities at the labor market entry.

Further, we investigate numerically how the EPL and the minimum wage affect the optimal wage profiles of a menu of contracts. A dynamic wage profile gives firms more flexibility in presence of firing costs. Indeed, the incentive for bad workers to accept the contract designed for them comes from the possibility to be dismissed if they do not. When the wage is constant, the firm decides either to fire or to retain the mismatched worker once observed the worker's ability. On the contrary, for an increasing wage profile, the worker could be dismissed later in employment, so that the punishment remains even in the presence of firing costs. The quantitative analysis suggests that the lowest levels of the EPL do not affect the optimal menu of contracts, while for the highest levels firms are unable to implement separating contracts. For intermediate values, the optimal wage profile designed for bad workers becomes slightly increasing. The firm still offers an increasing wage to good workers but with a higher growth rate and a lower initial wage in order to allow for dismissal and reduce the bad worker's incentives to shirk. Finally, we show that the presence of a minimum wage combined with a strict employment protection legislation prevents the implementation of separating contracts.

The paper proceeds as follows. In the next section we describe the model. Section 3 presents the optimal contracts designed for experienced workers whose ability is perfectly known. In section 4 we derive the optimal menu of contracts under adverse selection at the labor market entry. We develop more detailed properties for the case with a constant wage. Section 5 presents the job creation decisions and employment dynamics. Finally, in section 6 we solve numerically a version of model computed above French data and investigate quantitatively how labor market institutions affect the optimal wage profile and labor market outcomes.

2 The Model: Basic assumptions

This section describes our framework. We develop a dynamic principal-agent model to investigate the difficulties that arise when firms implement employment contracts under incomplete information and strict Employment Protection Legislation (EPL). By EPL, we refer to regulations concerning firing costs. The ultimate concern of the paper is to analyze how the labor market institutions affect the youth integration process by restraining firms in their labor contract's design. To feature the labor market entry process and job creation decisions, we thus rely on a standard matching model à la (Pissarides C. 2000) that integrates labor market frictions. It allows us to analyze the elasticity of the average entry unemployment duration with respect to the wage contract and then to the EPL. We do not investigate how a wage contracts could internalize the externalities associated with the matching process.

2.1 The environment:

There is a continuum of agents of measure one, who are either employed workers specialized in production or unemployed workers specialized in job search. We focus on the first years of employment on the labor market. Workers starting their working life are assumed to have the same education level but differ in their abilities. These differences are expressed by the output they produce in employment: $y = \{y^B; y^G\}$ with $y^G > y^B$. The output reflects the worker's capabilities: a low-productive worker is not able to produce y^G, independently of his effort. On-the-job effort and moral hazard issues will not be considered.

In each period, new workers enter the labor market as unemployed and search for a job. They are initially better informed about their abilities than employers while the fraction ψ of G-type entrants producing y^G is common knowledge. The firm has to experience the new worker to evaluate his capabilities. However, the information asymmetry does not prevail on the labor market: once engaged in a match, the firm observes the output flow produced by the worker and thus reveals his type after first producing. Following the empirical finding of (Schoenberg U. 2007) and (Schweri J. and Mueller B. 2008), we assume that the employer learning on worker's ability is symmetric. Firms learn both about the abilities of their own employees and about that of the other workers: the information is perfectly shared on the labor market. Once separated from their jobs, workers who have been revealed fall into the unemployment pool and do not have private information anymore. We thus distinguish two populations: new entrants and young revealed workers.

By assuming that new entrants have private information about their abilities that will be revealed in the employment relationship, we implicitly consider that young people never worked before their labor market entry. One can argue that this assumption is not consistent with the empirical evidence. Indeed, there is some kind of gradual labor market entry partly due to apprenticeship programmes and implying combinations of learning and working among young people within the European Union, ((OECD 1996a)). Similarly, the learning process on workers' abilities must be time-consuming and

based on the past information, as modeled by the learning theory ((Jovanovic B. 1979), (Harris M. and Holmstrom B. 1982)). The assumptions we adopt are a matter of convenience and allow us to easily compare the case with adverse selection with the full-information case.
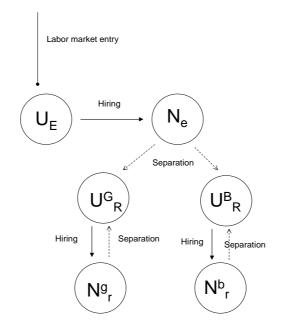
The basic environment borrows from the matching model à la (Pissarides C. 2000). The labor market is affected by search frictions so that searching for a job and searching for a worker are costly and time-consuming activities. In equilibrium, both vacancies and unemployment coexist. Firms are allowed to segment their search. Vacancies are offered either to new entrants whose type is not perfectly known, or to experienced workers whose type has already been revealed. We distinguish two main segments:

- At the labor market entry, job creation flows are driven by a constant return to scale matching function $m(u_E, v_E)$, with u_E the mass of new entrants and v_E the rate of vacancies directed to new entrants. The probability for the firm to fill a position and the probability for a new entrant to find a job are given respectively by $q(\theta_E) = \frac{m(u_E,v_E)}{v_E}$ and $p(\theta_E) = \frac{m(u_E,v_E)}{u_E}$, with $\theta_E = \frac{v_E}{u_E}$ the labor market entry tightness. From the standard properties of the matching function, we have $q'(\theta_E) < 0$ and $p'(\theta_E) > 0$.

- On a second segment, firms are free to post vacancies either to G-type or to B-type experienced workers who have been revealed. Workers and firms are matched together according to a standard matching function $m(u_R^i, v_R^i)$ for $i = \{B, G\}$ with u_R^i and v_R^i denoting respectively the mass of revealed i-type unemployed workers and the rate of vacancies posted to i-type workers. The probability for the firm to fill a position and the probability for a worker to find a job are given respectively by $q(\theta_R^i)$ and $p(\theta_R^i)$, with $\theta_R^i = \frac{v_R^i}{u_R^i}$. We have $q'(\theta_R^i) < 0$ and $p'(\theta_R^i) > 0$.

We differ from the basic theory of incentives by integrating an endogenous probability to find a job. It positively depends on the labor demand and negatively on the mass of unemployed workers. Workers find a job more easily when there are more jobs relative to job seekers competing for the offered vacancies. Similarly, firms are allowed to direct their search only to i-type revealed workers. In consequence, the matching process at the labor market entry integrates externalities associated with non-segmented search. It is straightforward that new entrants will find a job more easily when there are more good workers (for higher values of ψ). The search externalities pay a central role in the standard matching model. One could investigate how to internalize them in order to reach the efficient allocation. This is not the concern of our paper. The probability $p(\theta_E)$ will give us the average unemployment duration at the labor market entry under adverse selection, measured by $1/p(\theta_E)$, while probabilities $p(\theta_R^i)$ will give us the average unemployment duration of experienced workers under full information. The comparison between those two measures will allow us to investigate the evolution of employment prospects at the labor market entry under information asymmetry depending on the labor contract and on labor market institutions.

The basic time of event is the following: a match formed in t becomes productive in $t + 1$. Once job separation occurs, firms and workers are allowed to search next period. The labor market is represented as follows:

Figure 1: The segmented Labor market

2.2 The workers:

The preferences of the workers are

$$\sum_{t=0}^{\infty} \beta^t u(c_t), \tag{1}$$

where $\beta < 1$ is the discount factor and c_t the consumption. Agents are risk-adverse. We adopt the following CRRA utility function:

$$u(c) = \frac{c^{(1-\sigma)}}{(1-\sigma)} \tag{2}$$

with σ the relative risk aversion parameter. As is standard, the function u is increasing and concave. There is no savings so that employees consume their labor income w while job searchers of type i enjoy some real return $b_i = by^i$. As standard, b_i integrates unemployment insurance benefits and a measure of home production. It is thus assumed to be indexed to the worker's ability.

2.3 The firms' problem:

There is a continuum of identical firms which objective is twofold.
The number of jobs is endogenously determined by free entry conditions: firms post employment

positions on the labor market at a cost c by unit of time until any incremental profit is exhausted. Besides, at the time of meeting, the employer offers a labor contract to the worker. All jobs are assumed to be hit by an idiosyncratic shock that render them unproductive at rate s. Then, given the exogenous job separation process, the contract specifies both the level of the labor income and its evolution for the whole employment period. Although a continuum of values for a wage w_t is perhaps most realistic, for simplicity it is assumed here that there are only two values. The labor contract is defined by an initial wage w_1 moving to w_2 with rate λ. The firm not only designs the two wage levels but also the rate at which a worker can be promoted. Thereafter, we refer to the period of employment during which the worker gets w_1 as "employment at first stage", and to the period during which the worker gets w_2 as "employment at second stage". As usual, firms are risk neutral and discount future flows at the same rate as the workers. The firm's problem differs according to the information they have at the time of meeting.

2.3.1 Full information: the experienced workers

Hiring an experienced worker is not risky as their ability is perfectly known. The firm offers a labor contract according to the worker's type:

$$\{w_{1,r}^j; w_{2,r}^j; \lambda_r^j\}$$

The subscribe $j = \{b; g\}$ denotes the contracts designed for agents of type B and G respectively. The optimal contract is the one that maximizes the expected-discounted profit of the filled job and at least guarantees to workers the gain from unemployment so as to ensure their participation. When designing the labor contract, the firm takes the labor market tightness as given.

2.3.2 Adverse selection: the labor market entry

Firms have difficulties in observing the true ability of heterogenous workers at the labor market entry. Private information creates problems for both workers and firms. Firms want to be able to identify the workers' type so as to remunerate them according to the output they produce and to their reservation wage. On the other hand, high productive workers do not want to compete against low productive ones.

As most of the European countries are characterized by downward wage rigidities, we follow (Bai C. 1997) and consider that the wages cannot be contingent on the ability's observation. Optimal contracts will be thus analyzed under full commitment. However, we integrate the possibility for the firm to dismiss a worker who has been revealed by paying a firing cost F. The level F determines the strictness of the Employment Protection Legislation (EPL). The output y^G is assumed to be such that firms will never be induced to fire high-productive workers while the dismissal of low-productive workers depends on the offered wage and on the level of firing costs. Job destruction flows are driven by both an exogenous and an endogenous process.

Two types of contracts are considered. The separating contract is characterized by a menu of labor contracts the employers can use as a self-selection mechanism to reveal the worker's ability. The pooling contract is offered by employers who are not allowed or able to discriminate. The two contracts are defined as follows:

- **Pooling contract:**

  The labor contract specifies a single wage profile offered to both G-type and B-type entrants but an endogenous separation probability that depends on the worker's ability:

  $$\{w_{1,e}; w_{2,e}; \lambda_e; d(y^i)\}$$

  The optimal wage profile is the one that maximizes the average expected profit of a job and ensures the worker's participation. When designing the labor contract, the firm takes the labor market tightness as given.

  Separations with high-productive workers are only driven by the exogenous process: $d(y^G) = 0$. The firm decides whether or not to retain a worker who is revealed to be low-productive according to firing costs and to the wage level. If the worker is retained, the endogenous separation rate, under the condition that the job is not exogenously destructed, is $d(y^B) = 0$. If the worker is laid off, the employment relationship ends at the output observation, $d(y^B) = 1$. However, as the wage can vary over time, the employer has the possibility to dismiss a B-type worker either at stage 1 or at stage 2 of employment. The endogenous separation probability is given by respectively $d(y^B) = (1 - \lambda_e)$ and $d(y^B) = \lambda_e$, (Recall that a job starts at level w_1 and moves to level w_2 with rate λ_e). As firing costs are known at the time of meeting, so is the value of $d(y^i)$ and the average employment duration.

- **Separating contract:**

  The firm offers a menu of contracts that induces self selection from workers. It specifies a wage profile $j = \{g, b\}$ designed for G-type or B-type workers as well as an endogenous separation probability for i-type workers who did not choose the contract designed for them:

  $$\{w_{1,e}^j; w_{2,e}^j; \lambda_e^j; d^j(y^i)\} \quad for \quad j = \{b, g\}$$

  Workers who chose the right contract will not be fired, unless the job is hit by a shock at rate s. On the contrary, in case of mismatch, the firm decides whether or not to retain the worker once revealed according to the wage contract and to the level of firing costs: $d^j(y^i) = \{0; \lambda_e^j; (1-\lambda_e^j); 1\}$. The optimal menu of contracts is the one that maximizes the average expected profit of a job, ensures the worker's participation and the worker's selection of the contract that was designed for him. When designing the labor contract, the firm takes the labor market tightness as given.

As stated previously, we assume that the wage's level cannot be contingent on the ability's observation while the dismissal probability is. In consequence, when a menu of contracts is implemented,

a bad worker who chose the contract designed for good workers cannot face a wage's reduction but can be dismissed once revealed according to the strictness of the EPL. One can argue that this is a strong assumption that reduces the firm's flexibility when designing labor contracts. It is. Moreover, it should not be optimal: a worker might prefer, as the firm, a wage reduction instead of separation. However, it allows us to investigate how features of the European labor market institutions as wage rigidities and EPL affect the implementation of separating contracts.

Next, as only two wage levels are assumed, we constrain the firm in the optimal wage profile's design. Therefore, the effects of the EPL should be overestimated. The aim of the paper is mainly to give the intuition of the impact of the EPL on wage profiles and its implications on the labor market entry process. To deepen the analysis, we should investigate the optimal continuous wage w_t.

We now turn to investigate the effects of the labor market institutions as the EPL and the minimum wage on the optimal menu of contracts and analyze both under which conditions a menu of contracts could be implement and will be preferred to a pooling contract from the firm's point of view. Recall that the optimal wage contracts are derived for a given labor market tightness. Section 5 presents the job creation decisions and numerical exercises will allow us to provide a general equilibrium analysis with θ_E and θ_R^i endogenously determined.

3 The optimal labor contracts under full-information: The segment of experienced workers

Firms perfectly observe the type of experienced workers and thus offer at the time of meeting, a labor contract j that maximizes the expected return of a job $\Pi_{1,r}^j$ while ensuring the participation of workers. The expected return $\Pi_{1,r}^j$ satisfies:

$$\Pi_{1,r}^j = y^i - w_{1,r}^j + \beta(1-s)\left\{\lambda_r^j \Pi_{2,r}^j + (1-\lambda_r^j)\Pi_{1,r}^j\right\} \tag{3}$$

Current period profits are $(y^i - w_{1,r}^j)$. Jobs are exogenously destructed with rate s. As there is free entry, the expected value of a vacant post reduces to zero. If the job is not destructed and if employment evolves to stage 2 with rate λ_r^j, the firm gets $\Pi_{2,r}^j$ solving:

$$\Pi_{2,r}^j = y^i - w_{2,r}^j + \beta(1-s)\Pi_{2,r}^j \tag{4}$$

Similarly we derive the expected values to a i-type revealed worker of unemployment and employment, under the condition that the worker accepts the labor contract offered by the firm:

$$U_R^i = u(b^i) + \beta\left\{p(\theta_R^i)V_{1,r}^j + [1 - p(\theta_R^i)]U_R^i\right\} \tag{5}$$

$$V_{1,r}^j = u(w_{1,r}^j) + \beta s U_R^i + \beta(1-s)\left\{\lambda_r^j V_{2,r}^j + (1-\lambda_r^j)V_{1,r}^j\right\} \tag{6}$$

$$V_{2,r}^j = u(w_{2,r}^j) + \beta s U_R^i + \beta(1-s)V_{2,r}^j \tag{7}$$

The firm's problem can be stated as:

$$\max_{w_{1,r}^j; w_{2,r}^j, \lambda_r^j} \Pi_{1,r}^j$$

subject to the participation constraint

$$V_{1,r}^j \geq U_R^i \qquad (8)$$

Proposition 1 *The optimal labor contract j under full information is constant,*

$$w_{1,r}^j = w_{2,r}^j = w_r^j \qquad \forall \lambda_r^j$$

and gives the worker the same utility as unemployed, so that the participation constraint is saturated $V_r^j = U_R^i$. Given our assumption on the utility function, the complete information optimal contracts are:

$$w_r^g = b^G \qquad and \qquad w_r^b = b^B$$

The assumption of unemployment income indexed to worker's productivity ensures that $w_r^g > w_r^b$. The firm's problem resolution is provided in Appendix 8.1.

4 The optimal wage profile under adverse selection: The labor market entry

If there is no information asymmetry, the distinction between new entrants and experienced workers no longer holds. The optimal contracts under full information are such that all workers obtain the same utility level of their outside option: $w_e^g = b^G$ and $w_e^b = b^B$. In the presence of adverse selection, the optimal contract is usually a separating menu of contracts that elicits the worker's private information by giving up some information rent. In his maximization problem, the firm has to guarantee both participation and incentive compatibility due to adverse selection. The job offer must be such that only workers who truly possess the abilities they claim to possess would accept the job. The firm's problem can be stated as:

$$\max_{w_{1,e}^j; w_{2,e}^j, \lambda_e^j} \Pi_E = \left\{ \psi \Pi_{1;e}^{g,G} + (1-\psi) \Pi_{1,e}^{b,B} \right\}$$

subject to the participation constraints

$$V_{1,e}^{G,g} \geq U_R^G \qquad (PC_G^1)$$
$$V_{1,e}^{B,b} \geq U_R^B \qquad (PC_B^1)$$
$$V_{2,e}^{G,g} \geq U_R^G \qquad (PC_G^2)$$
$$V_{2,e}^{B,b} \geq U_R^B \qquad (PC_B^2)$$

and to the adverse selection incentive constraints

$$V_{1,e}^{G,g} \geq V_{1,e}^{G,b} \qquad (IC_G)$$
$$V_{1,e}^{B,g} \geq V_{1,e}^{B,g} \qquad (IC_B)$$

As the worker's ability is revealed after first producing, the firm has to ensure that the value of employment both at stage 1 and 2 is higher than the value of revealed unemployment, U_R^i. Under full commitment, a worker who accepts the contract j at the time of meeting is not allowed to renegotiate when evolution to $w_{2,e}^j$ occurs. The incentive constraints then specify that the expected employment value $V_{1,e}^{i,j}$ with $i = j$ has to be higher than the expected employment value associated with mismatch, $V_{1,e}^{i,j}$ with $i \neq j$. This value is an expected one which thus integrates the evolution to employment at stage 2 with rate λ_e^j.

The values of employment to the firm and to the worker for the case where workers choose the contract designed for them, $i = j$, satisfy:

$$\Pi_{1,e}^{i,j} = y^i - w_{1,e}^j + \beta(1-s)\left\{\lambda_e^j \Pi_{2,e}^{i,j} + (1-\lambda_e^j)\Pi_{1,e}^{i,j}\right\} \tag{9}$$

$$\Pi_{2,e}^{i,j} = y^i - w_{2,e}^j + \beta(1-s)\Pi_{2,e}^{i,j} \tag{10}$$

$$V_{1,e}^{i,j} = u(w_{1,e}^j) + \beta s U_R^i + \beta(1-s)\left\{\lambda_e^j V_{2,e}^{i,j} + (1-\lambda_e^j)V_{1,e}^{i,j}\right\} \tag{11}$$

$$V_{2,e}^{i,j} = u(w_{2,e}^j) + \beta s U_R^i + \beta(1-s)V_{2,e}^{i,j} \tag{12}$$

Recall that according to the free entry condition, the value of a vacancy reduces to zero in equilibrium. As the agent's type is revealed after first producing, the firm identifies a <u>mismatch</u> if the worker did not choose the contract designed for him. Employers decide whether or not to dismiss mismatched workers according to the level of firing costs and to the wage contract. Thus the expected employment values to the mismatched worker depends on the firm's separation decision. We now turn to analyze the incentive constraints.

4.1 The incentive constraints

The expected value of a job paid $w_{1,e}^j$ and occupied by a <u>mismatched worker</u> is given by:

$$\Pi_{1,e}^{j,i} = y^i - w_{1,e}^j + \beta(1-s)\left\{\lambda_e^j \max\left[\Pi_{2,e}^{j,i}; -F\right] + (1-\lambda_e^j)\max\left[\Pi_{1,e}'^{j,i}; -F\right]\right\} \tag{13}$$

Recall that i denotes the worker's type and j the contract's type. For the mismatch case, we have $i \neq j$. The firm gets current profits $y^i - w_{1,e}^j$. At the end of the period, if evolution to the second level of wage $w_{2,e}^j$ occurs with rate λ_e^j, the firm decides to retain the mismatched worker on employment only if $\Pi_{2,e}^{j,i} \geq -F$. The expected profit $\Pi_{2,e}^{j,i}$ the firm gets under job continuation at second stage is given by:

$$\Pi_{2,e}^{j,i} = y^i - w_{2,e}^j + \beta(1-s)\Pi_{2,e}^{j,i} \tag{14}$$

Now if evolution to $w_{2,e}^j$ does not occur, the firm decides to retain the mismatched worker on employment only if $\Pi_{1,e}'^{j,i} \geq -F$. The expected profit under job continuation at first stage is given by:

$$\Pi_{1,e}'^{j,i} = y^i - w_{1,e}^j + \beta(1-s)\left\{\lambda_e^j \max\left[\Pi_{2,e}^{j,i}; -F\right] + (1-\lambda_e^j)\Pi_{1,e}'^{j,i}\right\} \tag{15}$$

The firing decision at first stage obviously depends on the decision that will be taken at the second stage of employment. We distinguish four cases according to the firm's separation decision:

1. The firm fires the mismatched worker once he is revealed. The separation probability is thus 1.

2. The firm fires the mismatched worker only at second stage of employment, for $w_{2,e}^j$. The separation probability is $s + (1-s)\lambda_e^j$.

3. The firm fires the mismatched worker only at first stage of employment, for $w_{1,e}^j$. The separation probability is $s + (1-s)(1-\lambda_e^j)$.

4. The firm retains the mismatched worker. Destructions are only driven by the exogenous process with rate s.

Let us now derive the conditions under which each case emerges and the corresponding expected employment values to a mismatched worker.

1. **The firm fires the mismatched worker once he is revealed**

   This case occurs when the expected profits of employment are such that

   $$\Pi_{2,e}^{i,j} \leq -F \quad and \quad \Pi_{1,e}'^{i,j} \leq -F$$

   The worker is thus dismissed whatever the stage of employment. According to equation 14, we define a threshold wage value such that $\Pi_{2,e}^{i,j} = -F$:

   $$\hat{w^j} = y^i + [1 - \beta(1-s)]F \tag{16}$$

   The mismatched worker is dismissed at stage 2 of employment if $w_{2,e}^j \geq \hat{w^j}$. Now given that the separation is optimal at stage 2, the expected profit of employment at stage 1 solves:

   $$\Pi_{1,e}'^{i,j} = \frac{y^i - w_{1,e}^j - \beta(1-s)\lambda_e^j F}{1 - \beta(1-s)(1-\lambda_e^j)}$$

   Similarly, we show that $w_{1,e}^j \geq \hat{w^j}$ entails $\Pi_{1,e}'^{i,j} \leq -F$. To conclude, a wage contract such that

   $$w_{1,e}^j \geq \hat{w^j} \quad and \quad w_{2,e}^j \geq \hat{w^j}$$

   allows firms to dismiss the mismatched worker once revealed.
   The expected value of employment for a i-type mismatched worker therefore satisfies:

   $$V_{1,e}^{i,j} = u(w_{1,e}^j) + \beta U_R^i \tag{17}$$

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2. **The firm fires the mismatched worker only at the second stage of employment**

This case occurs when the expected profits of employment are such that

$$\Pi_{2,e}^{i,j} \leq -F \quad and \quad \Pi_{1,e}^{\prime i,j} > -F$$

In consequence, a wage contract such that

$$w_{1,e}^{j} \geq \hat{w}^{j} \quad and \quad w_{2,e}^{j} < \hat{w}^{j}$$

allows the firm to retain a mismatched worker at first stage but to fire him once evolution to $w_{2,e}^{j}$ occurs. This cases thus emerges with an increasing wage: $w_{2,e}^{j} > w_{1,e}^{j}$. The expected value of employment for a i-type mismatched worker satisfies:

$$V_{1,e}^{i,j} = u(w_{1,e}^{j}) + \beta[s + (1-s)\lambda_{e}^{j}]U_{R}^{i} + \beta(1-s)(1-\lambda_{e}^{j})V_{1,e}^{i,j} \tag{18}$$

3. **The firm fires the mismatched worker only at the first stage of employment**

This case occurs when the expected profits of employment are such that

$$\Pi_{2,e}^{i,j} > -F \quad and \quad \Pi_{1,e}^{\prime i,j} \leq -F$$

The condition $w_{2,e}^{j} \leq \hat{w}^{j}$ entails $\Pi_{2,e}^{i,j} > -F$. Given that the job continuation is an optimal decision at stage 2, the expected profit of employment at stage 1 solves:

$$\Pi_{1,e}^{\prime i;j} = \frac{y^{i} - w_{1,e}^{j} + \beta(1-s)\lambda_{e}^{j}\Pi_{2,e}^{i;j}}{1 - \beta(1-s)(1-\lambda_{e}^{j})}$$

According to this expression, we define a threshold wage value such that $\Pi_{1,e}^{\prime i,j} = -F$:

$$\tilde{w}^{j} = \hat{w}^{j} + \frac{\beta(1-s)\lambda_{e}^{j}}{1 - \beta(1-s)(1-\lambda_{e}^{j})}(y^{i} - w_{2,e}^{j}) \tag{19}$$

One should notice that $\tilde{w}^{j} > \hat{w}^{j}$. We show that the case where $\Pi_{2,e}^{i,j} > -F$ and $\Pi_{1,e}^{\prime i,j} \leq -F$ emerges for a wage contract such that:

$$w_{2,e}^{j} \leq \hat{w}^{j} \quad and \quad w_{1,e}^{j} \geq \tilde{w}^{j} > \hat{w}^{j}$$

Contrary to the second case, this situation requires a decreasing wage contract. The firm will retain the worker only with a wage reduction that occurs at rate λ_{e}^{j}. Numerical exercises will show that this case never emerges in equilibrium. The expected values of employment for a i-type mismatched worker are given by:

$$V_{1,e}^{i,j} = u(w_{1,e}^{i}) + \beta[s + (1-s)(1-\lambda_{e}^{j})]U_{R}^{i} + \beta(1-s)\lambda_{e}^{j}V_{2,e}^{i,j} \tag{20}$$

$$V_{2,e}^{i,j} = u(w_{2,e}^{i}) + \beta(1-s)V_{2,e}^{i,j} \tag{21}$$

4. **The firm retains the mismatched worker**:

Finally, this last case occurs when the expected profits of employment are such that

$$\Pi_{2,e}^{i,j} > -F \quad and \quad \Pi_{1,e}'^{i,j} > -F$$

A wage contract such that

$$w_{2,e}^{j} \leq \hat{w}^{j} \quad and \quad w_{1,e}^{j} \geq \tilde{w}^{j}$$

does not allow the firm to dismiss the mismatched worker. The expected values of employment for a i-type mismatched worker are thus given by:

$$V_{1,e}^{i,j} = u(w_{1,e}^{i}) + \beta s U_{R}^{i} + \beta(1-s)\left\{\lambda_{e}^{j}V_{2,e}^{i,j} + (1-\lambda_{e}^{j})V_{1,e}^{i,j}\right\} \tag{22}$$

$$V_{2,e}^{i,j} = u(w_{2,e}^{i}) + \beta(1-s)V_{2,e}^{i,j} \tag{23}$$

Recall that the level of the EPL is common knowledge. At the time of meeting, the firm offers a menu of labor contracts that specifies both the wage dynamic and the dismissal probability for mismatched workers. The dismissal represents a sanction that induces the worker to accept the contract designed for him. It is straightforward that G-type workers should not be induced to choose the b-type contract but if they do, they will not be fired: The fourth case systematically emerges for $\{i = G; j = b\}$.

Let us consider mismatch arising when low-productive workers accepting the contract designed for G-type workers, $\{i = B; j = g\}$. Implementing a menu of contracts such that both wage levels designed for G-type workers are higher than the threshold $\hat{w}^{g}$ enables self-selection from B-type workers, (c.f. first case). The threshold $\hat{w}^{j}$ is increasing in the level of firing costs: the higher the firing costs, the higher the wage that prevents mismatch. However, firms have to offer wage levels $(w_{1,e}^{g}; w_{1,e}^{g})$ that are low enough to get a positive expected profit of a match with a G-type worker, $\Pi_{1,e}^{G,g}$. We thus expect the first case to emerge for low EPL. The optimal wage contract under adverse selection should be characterized by a menu of separating contracts. On the contrary, the fourth case should emerge for high EPL. High levels of firing costs require that the firm offers a higher value of w_{e}^{g} to be able to dismiss mismatched workers. If the wage contract is such that $\Pi_{1,e}^{G,g} < 0$, the EPL prevents firms from dismissing mismatched workers and thus from implementing a menu of separating contracts. The optimal wage contract under adverse selection should be characterized by a pooling contract offered to both types of workers.

Offering a constant transfer is an optimal decision under full information but may not be under adverse selection. The seminal papers of (Lazear E.P. 1981) and (Harris M. and Holmstrom B. 1982) provided theoretical support to an upward slopping wage-job tenure profile. We expect the optimal wage profile designed for good workers to be increasing while firms should offer to bad workers a

flatter wage. Allowing for a time-varying wage increases firm's flexibility and gives room for implementing a menu of separating contracts even with high firing costs. Indeed, firing costs impede the dismissal of low-productive shirkers. But the firm can modify the wage profile designed for good workers to keep the punishments if bad workers do not choose the right contract. By strongly reducing the initial wage $w_{1,e}^g$ and increasing the second wage level $w_{2,e}^g$, the firm remains able to dismiss mismatched workers at the second stage of employment. The dismissal probability falls from 1 to λ_e^g. The threat point of the firm is thus lower than in the absence of firing costs but higher than for the highest levels of EPL. Typically, we expect the firing costs to gradually reduce the dismissal probability from 1, to λ_e^g and finally to 0, so that the first, second and fourth cases emerge accordingly.

A parameterized version of the model will be solved numerically in the last section so as to determine the optimal wage contract under adverse selection according to the the labor market institutions that characterized most of the European countries: high level of EPL and minimum wage. To account for the presence of a minimum wage, we introduce four additional constraints to the firm's maximization problem:

$$w_{1,e}^j \geq \bar{w} \quad and \quad w_{2,e}^j \geq \bar{w} \quad \forall \, j = \{b, g\}$$

The minimum wage could prevent firms from reducing the initial wage $w_{1,e}^g$ in presence of firing costs, thereby making impossible the implementation of a menu of separating contracts.

In order to derive analytical results and to highlight the main effects of the EPL, we propose to solve the firm's problem for a constant wage w_e^j, thus setting $\lambda_e^j = 0$. It is straightforward that the firm's dismissal decision becomes binary: the mismatched worker is either laid off with probability 1, or retained with exogenous rate $(1 - s)$. The two intermediate cases cannot emerge anymore, thus reducing room for the designing of self-selection mechanisms.

4.2 The case with a constant wage: w_e^j

Assume that the menu of labor contracts offered to new entrants specifies a constant wage, w_e^j. The firm's problem can be stated as:

$$\max_{w_e^g, w_e^b} \Pi_E \left\{ \psi \Pi_e^{G,g} + (1 - \psi) \Pi_e^{B,b} \right\}$$

subject to the participation constraints

$$V_e^{G,g} \geq U_R^G \qquad\qquad (PC_G)$$
$$V_e^{B,b} \geq U_R^B \qquad\qquad (PC_B)$$

and to the adverse selection incentive constraints

$$V_e^{G,g} \geq V_e^{G,b} \qquad\qquad (IC_G)$$
$$V_e^{B,g} \geq V_e^{B,g} \qquad\qquad (IC_B)$$

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The expected values of employment to a firm and to a worker who accepts the contract designed for him (for $i = j$) satisfy:

$$\Pi_e^{i,j} = y^i - w_e^j + \beta(1-s)\Pi_e^{i,j} \tag{24}$$

$$V_e^{i,j} = u(w_e^j) + \beta s U_R^i + \beta(1-s)V_e^{i,j} \tag{25}$$

Once engaged in production, mismatched workers are identified. The expected value of a job occupied by a i-type mismatched worker (for $i \neq j$) is given by:

$$\Pi_e^{i,j} = y^i - w_e^j + \beta(1-s)\max\{\Pi_e^{\prime i,j}; -F\} \tag{26}$$

The worker will be retained on the contract he accepted only if the expected profit under job continuation is higher than the firing cost: $\Pi_e^{\prime i,j} \geq -F$, with:

$$\Pi_e^{\prime i,j} = y^i - w_e^j + \beta(1-s)\Pi_e^{\prime i,j} \tag{27}$$

4.2.1 The incentive constraints

Two cases emerge depending on the labor contract and on the value of firing costs, F:

1. If the expected profit of employment is such that $\Pi_e^{\prime i,j} \leq -F$, **the firm decides to fire the mismatched worker**. According to equation 27, this case occurs when the wage contract is such that

$$w_e^j \geq y^i + [1 - \beta(1-s)]F$$

   The expected value of employment for a i-type mismatched worker thus satisfies:

$$V_e^{i,j} = u(w_e^j) + \beta U_R^i \quad for \ \ i \neq j \tag{28}$$

2. If the expected profit of employment is such that $\Pi_e^{i,j} \geq -F$, **the firm decides to retain the mismatched worker**. In consequence, for a wage contract such that

$$w_e^j \leq y^i + [1 - \beta(1-s)]F$$

   firms will be unable to dismiss a mismatched worker. The expected value of employment for a i-type mismatched worker thus satisfies:

$$V_e^{i,j} = u(w_e^j) + \beta s U_R^i + \beta(1-s)V_e^{i,j} \quad for \ \ i \neq j \tag{29}$$

We define the reservation threshold of the wage above which the mismatched worker will be fired as:

$$\hat{w}^j = y^i + [1 - \beta(1-s)]F \quad for \ \ i \neq j \tag{30}$$

It is straightforward that G-type workers who choose the contract designed for B-type workers will be retained so that the first case never emerges[3]. Indeed, the firm offers a wage $w_e^b \leq y^B$ in order

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[3]There should be no incentive for high-productive workers to choose the b-type wage. However, the value $V_e^{G,b}$ has to be derived in order to solve the firm's problem.

to get an expected profit $\Pi_e^{B,b} \geq 0$. Then, the wage w_e^b is necessarily lower than the threshold $\hat{w}^b = y^G + [1 - \beta(1-s)]F$ so that $\Pi_e^{G,b} \geq -F$.

The two cases can theoretically emerge for low productive workers. The firm offers a wage w_e^g ensuring $\Pi_e^{G,g} \geq 0$, so that the dismissal of B-type mismatched workers is possible if $\hat{w}^g < w_e^g \leq y^G$ The threshold $\hat{w}^g$ increases with firing costs. High EPL impedes the dismissal of B-type mismatched workers thus preventing firms from implementing separating contracts.

4.2.2 The optimal separating contracts

We derive the optimal labor contracts the firm offers according to the strictness of the EPL. The resolution is provided in Appendix 8.2 and yields to the following set of propositions:

Proposition 2 *For a low level of firing costs:*

$$F \leq \bar{F}_1 \quad with \quad \bar{F}_1 = \frac{b^G - y^B}{[1 - \beta(1-s)]}$$

The optimal menu of contracts that elicit workers' private information entails:

- *The same utility as unemployed for G-type worker, $u(w_e^g) = u(b^G)$. Given our assumptions on the utility function: $w_e^g = b^G$. The optimal wage designed for G-type workers under adverse selection is similar to the one under full information.*

- *A positive information rent to the B-type worker: $u(w_e^b) > u(b^B)$. The wage satisfies:*

$$u(w_e^b) = u(b^G) - \beta(1-s)[u(b^G) - u(b^B)]$$

Our findings in the absence of firing costs are standard results. The optimal wage contract under adverse selection is such that the participation constraint is saturated for high-productive workers while the firm has to give up some information rent to low-productive workers in order to elicit the worker's private information. Thus, the incentive constraint is saturated only for B-type workers. The information rent B-type workers get provides them an additional utility:

$$u(w_e^b) - u(b^B) = [1 - \beta(1-s)][u(b^G) - u(b^B)]$$

According to equation 30, this contract can be implemented for $F \leq \bar{F}_1$, which would ensure that $w_e^g > \hat{w}^g$:

$$b^G > y^B + [1 - \beta(1-s)]F$$

Firms proceed with the dismissal of B-type mismatched workers once revealed. The analysis suggests that for low values of F, the optimal contract under adverse selection is able to induce B-type workers to accept the contract designed for them. Only B-type workers get an information rent. An increase in firing costs such that F remains lower than $\bar{F}_1$ does not affect the optimal menu of contracts.

Proposition 3 *For an intermediate level of firing costs:*

$$\bar{F}_1 < F \leq \bar{F}_2 \quad with \quad \bar{F}_2 = \frac{y^G - y^B}{[1 - \beta(1-s)]}$$

The optimal menu of contracts that elicits workers' private information entails:

- *A positive information rent to the G-type worker: $u(w_e^g) > u(b^G)$. The wage satisfies:*

$$w_e^g = \hat{w}^g \quad \Longrightarrow \quad w_e^g = y^B + [1 - \beta(1-s)]F < y^G$$

- *A positive information rent to the B-type worker: $u(w_e^b) > u(b^B)$. The wage satisfies:*

$$u(w_e^b) = u(w_e^g) - \beta(1-s)[u(w_e^g) - u(b^B)]$$

On the contrary, for intermediate values of F, a wage contract $w_e^g = b^G$ will induce B-type workers to choose the contract designed for G-type workers as they will not be dismissed. Indeed, according to the threshold $\bar{F}_1$, firing costs such that $F > \bar{F}_1$ entails $b^G > y^B + [1 - \beta(1-s]F$. Then, the wage w_e^g will be lower than the threshold value $\hat{w}_e^g$ (equation 30) preventing firms from dismissing mismatched workers. As a result, firms have to offer $w_e^g > b^G$ in order to drive the expected profit $\Pi_e^{B,g}$ under the value of firing costs and to remain able to dismiss mismatched workers: the implementation of a menu of separating contracts thus requires a reduction of $\Pi_e^{G,g}$ to prevent mismatch. Firms have to give up some information rent to both types of workers. The optimal wage is $w_e^g = \hat{w}^g$ and the incentive constraint of B-type workers remains saturated. To sum up, high productive workers receive a constant wage $w_e^g = b^G$, whatever the value of firing costs as long as $F < \bar{F}_1$ while the wage w_e^g increases with firing costs for $\bar{F}_1 < F \leq \bar{F}_2$. The higher the firing costs in the range of $[\bar{F}_1; \bar{F}_2]$, the higher the information rent.

Proposition 4 *For a high level of firing costs:*

$$F > \bar{F}_2$$

The optimal contract is a single value of w_e that gives all workers the same utility as G-type unemployment. Given our assumptions on the utility function, the optimal wage is $w_e = b^G$. It entails:

- *The same utility as unemployed for G-type worker, $u(w_e) = u(b^G)$. The optimal wage designed for G-type workers under adverse selection is similar to the one under full information.*

- *A positive information rent to the B-type worker: $w_e > b^B$.*

For a level of firing costs higher than the discounted difference of outputs, $F > \bar{F}_2$, the level of the threshold $\hat{w}^g$ now exceeds the output y^G. In order to get $\Pi_e^{G,g} \geq 0$, the firm necessarily offers a wage

$$w_e^g < y^G < \hat{w}^g$$

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In consequence, B-type mismatched workers will not be laid off. As firms cannot prevent mismatch, the menu of contracts that elicits private information cannot be implemented. In order to ensure the participation of G-type workers, the firm has to give up the highest information rent to B-type workers who get an additional utility

$$u(w_e^b) - u(b^B) = [u(b^G) - u(b^B)]$$

The difference between the two thresholds is given by:

$$\bar{F}_2 - \bar{F}_1 = \frac{y^G - b^G}{[1 - \beta(1-s)]}$$

The range of values for which the firm has to give up an information rent to high productive workers is given by the discounted gap between the output produced in employment and home production. In consequence, for $b^G < y^G$, the firm has room to implement a menu of contracts even with firing costs.

4.2.3 Separating vs. pooling contracts

The analysis suggested that for a high level of firing costs, a separating menu of contracts cannot be implemented. We ask whether or not for an intermediate value of the EPL, $\bar{F}_1 < F \leq \bar{F}_2$, the separating contract that gives all the workers an information rent is optimal with respect to the pooling contract. The pooling contract is the one that offers a single wage w_e to both high-productive and low-productive workers.

The firm's problem can be stated as:

$$\max_{w_e} \left\{ \psi \Pi_e^G + (1 - \psi) \Pi_e^B \right\}$$

subject to the participation constraints

$$V_e^G \geq U_R^G$$
$$V_e^B \geq U_R^B$$

Under full commitment, the labor contract is not assumed to be renegotiated but employers have the possibility to fire a worker who has been revealed to be low productive by paying a dismissal cost F. The expected value of a job occupied by a B-type worker satisfies:

$$\Pi_e^B = y^B - w_e + \beta(1-s) \max\{\Pi_e'^B, -F\} \tag{31}$$

with $\Pi_e'^B$ the expected profit from job continuation:

$$\Pi_e'^B = y^B - w_e + \beta(1-s)\Pi_e'^B \tag{32}$$

The condition under which a B-type worker will be fired is thus given by:

$$\frac{y^B - w_e}{[1 - \beta(1 - s)]} < -F \tag{33}$$

The optimal contract does not depend on the firm's separation decision. It yields the following proposition:

Proposition 5 *The optimal wage w_e is the one that ensures G-type workers participation. It entails*

- *The same utility as unemployed for G-type worker, $u(w_e) = u(b^G) \implies w_e = b^G$*

- *A positive information rent to the B-type worker: $w_e > b^B$*

- *The dismissal of B-type workers for $F < \bar{F}_1$.*

Let's now consider values of firing costs in the range of $\bar{F}_1$ and $\bar{F}_2$. We derive the difference between the expected profit Π_E the firm gets when offering a menu of contract and when offering a pooling contract. It simplifies to:

$$\frac{\psi\{b^G - y^B - [1 - \beta(1 - s)]F\} + (1 - \psi)(b^G - w_e^b)}{[1 - \beta(1 - s)]} \tag{34}$$

For $F = \bar{F}_1$, the profit gap equals

$$(1 - \psi)\frac{b^G - w_e^b}{[1 - \beta(1 - s)]}$$

which has positive value when the optimal separating contract is such that $b^B < w_e^b < b^G$. We expect the menu of contracts to be preferred to the pooling contract for values of firing costs close to $\bar{F}_1$. The profit gap is reduced by and increase in F. We show that:

Proposition 6 *There is a threshold value $\tilde{F}$ such that $\bar{F}_1 < \tilde{F} \le \bar{F}_2$, above which the pooling contract will be preferred to the separating one. It satisfies:*

$$\tilde{F} = \frac{b^G - \psi y^B - (1 - \psi)w_e^b}{\psi[1 - \beta(1 - s)]} \tag{35}$$

As w_e^b depends on the level of firing costs, F, a more stringent EPL also reduces the threshold $\tilde{F}$.

To sum up, for intermediate levels of the EPL, the firm faces a trade-off between conceding a higher wage level w_e^g to good workers that would induce bad workers to choose the contract designed for them as they will be dismissed if not, or conceding the same wage to bad workers as to good workers. They compare the loss in $\Pi_e^{G,g}$ a menu of contracts would imply with the loss in Π_e^B a pooling contract would imply. This trade-off thus not only depends on the level of firing costs, but also on the fraction of good workers:

$$\frac{\partial \tilde{F}}{\partial \psi} = -\frac{(b^G - w_e^b)}{\psi^2[1 - \beta(1-s)]} < 0$$

For a given level of firing costs, firms will be more likely to increase w_e^g in order to implement a menu of separating contracts if the fraction of good workers is low. The higher the fraction of bad workers $(1 - \psi)$, the higher the threshold $\tilde{F}$.

5 The labor market equilibrium

We first describes how job creation decisions are taken, given the labor contracts offered new entrants and to revealed experienced workers.

5.1 Job creation decisions

Firms decide to what type of workers to direct their search. The expected profits of an unfilled position directed either to a G-type or to a B-type revealed worker are given by:

$$\Pi_{G,R}^v = -c + \beta\left\{q(\theta_R^G)\Pi_{1;r}^g + [1 - q(\theta_R^G)]\Pi_{G,R}^v\right\} \tag{36}$$

$$\Pi_{B,R}^v = -c + \beta\left\{q(\theta_R^B)\Pi_{1;r}^b + [1 - q(\theta_R^B)]\Pi_{B,R}^v\right\} \tag{37}$$

The expected value of a vacancy directed to new entrants satisfies:

$$\Pi_E^v = -c + \beta\left\{q(\theta_E)\Pi_E + [1 - q(\theta^E)]\Pi_E^v\right\} \tag{38}$$

with Π_E, the average expected profit of a job occupied by a new entrant whose type is unknown. It can be written without loss of generality as:

$$\Pi_E = \psi\Pi_{1,e}^{G,g} + (1 - \psi)\Pi_{2,e}^{B,b} \tag{39}$$

This value depends on the optimal labor contract the firm offers, which is either a single contract or a menu of separating contracts. As there is free entry, the values of a vacancy reduce to zero. The tightness θ_R^i and θ_E are such that the expected cost of posting a vacancy equals the expected return of a filled job on each segment:

$$\frac{c}{q(\theta_R^i)} = \beta\Pi_{1,r}^j \tag{40}$$

$$\frac{c}{q(\theta_E)} = \beta\Pi_E \tag{41}$$

5.2 Labor market flows

L_t denotes the labor force at period t, which is growing at rate δ, so that:

$$L_{t+1} = (1 + \delta)L_t$$

The populations of G-type and B-type new entrants are thus given by respectively $\psi\delta L_t$ and $(1-\psi)\delta L_t$. Let us introduce the notations:

- $u_{E,t}^i = \frac{U_{E,t}^i}{L_t}$ denotes the mass of i-type unemployed workers who have private information and search for their first job,

- $u_{R,t}^i$ denotes the mass of i-type unemployed workers who have been revealed previously in employment,

- $n_{e,t}^i$ denotes the mass of i-type new workers who occupied their first job,

- $n_{r,t}^i$ denotes the mass of i-type experienced workers, which type was known by firms at the time of meeting.

The dynamic of the employment is given by the following set of equations:

$$u_{E,t+1}^G(1 + \delta) = \psi\delta + [1 - p(\theta_{E,t})]u_{E,t}^G \tag{42}$$

$$u_{E,t+1}^B(1 + \delta) = (1 - \psi)\delta + [1 - p(\theta_{E,t})]u_{E,t}^B \tag{43}$$

$$n_{e,t+1}^i(1 + \delta) = p(\theta_{E,t})u_{E,t}^i + (1 - s)n_{e,t}^i \tag{44}$$

$$u_{R,t+1}^i(1 + \delta) = s(n_{e,t}^i + n_{r,t}^i) + [1 - p(\theta_{R,t}^i)]u_{R,t}^i \tag{45}$$

$$n_{r,t+1}^i(1 + \delta) = p(\theta_{R,t}^i)u_{R,t}^i + (1 - s)n_{r,t}^i \tag{46}$$

Unemployment at the labor market entry is composed by the flow of new entrants starting their search in $t + 1$ and by workers who did not find a job at period t. Workers who are separated from their job fall into the unemployment pool of revealed workers and find a new job with probability $p(\theta_R^i)$.

5.3 The labor market equilibrium

Definition 1 *The steady-state equilibrium is characterized by a list θ_E, θ_R^i, $\{w_{1,r}^j; w_{2,r}^j; \lambda_r^j\}$, $\{w_{1,e}^j; w_{2,e}^j; \lambda_e^j; d_{y^i}^j\}$, u_E^i, u_R^i, n_e^i, and n_r^i for $i = \{G; B\}$ and $j = \{g; b\}$ such that*

1. *The free entry conditions given by equations 40 and 41 are verified,*

2. *The optimal wage contracts maximize the average expected discounted profit of a new job and guarantee both participation and incentive compatibility due to adverse selection that arises at the labor market entry,*

3. The flow equilibrium conditions:

$$u_E^G = \frac{\psi\delta}{(1+\delta) - [1 - p(\theta_E)]}$$

$$u_E^G = \frac{(1-\psi)\delta}{(1+\delta) - [1 - p(\theta_E)]}$$

$$n_e^i = \frac{p(\theta_E)u_E^i}{(\delta + s)}$$

$$u_R^i = \frac{s(n_e^i + n_r^i)}{(1+\delta) - [1 - p(\theta_R^i)]}$$

$$n_r^i = \frac{p(\theta_R^i)u_R^i}{(\delta + s)}$$

By preventing the firms from implementing a menu of separating contract, the EPL reduces the expected profit of a job at the labor market entry and thus moderates job creations. The labor market integration process of young workers should be smoother in the absence of any dismissal costs. However, as workers get an information rent, they should be better off with a strict EPL.

6 Numerical exercises

This section provides a numerical exercise to illustrate the effects of the labor market institutions on the optimal wage contract the firm offers to new entrants under adverse selection. It allow us to investigate the optimal wage profile by relaxing the assumption of a constant wage and to analyze the implications on the youth labor market integration process.

6.1 Computation

The month is taken as unit of time. We adopt the following Cobb-Douglas matching technology: $m(u_k, v_k) = mu^\varphi v^{1-\varphi}$, which is assumed to be identical for all matching processes. We choose an intermediate value for the relative risk aversion parameter: $\sigma = 2$.

The productivity of G-type workers is normalized to 1 while the values of y^B and ψ are computed arbitrarily. Adverse selection should emerge at the labor market entry for workers who have the same education level. The differences in workers abilities should be low so we assume a productivity gap of 10%. The fraction of G-type workers is fixed to 75%. Assuming a lower fraction would imply that for higher levels of EPL, the expected profit at the labor market entry, Π_E, has negative value such that no vacancies will be posted.

Then, the value of b that determines the unemployment income is computed so that firms will be able to dismiss B-type mismatched workers for $F = 0$. In this case, the optimal single wage w_e^g was demonstrated to equal the value of b^G. As firms will dismiss B-type mismatched workers if $y^B < w_e^g \leq y^G$, we choose $b = 0.95 > y^B$. Such a value implies that current profits will be quite low. However, it allows us ensure that the case where B-type mismatched workers are fired emerges. Then

we illustrate the effects of firing costs on the labor market.

Finally, the cost of a vacancy c is computed so that the probabilities to fill a vacancy $q(\theta_R^i)$ are in the range of $[0.71; 0.79]$, which is consistent with (Den Hann W.J., Ramey G. and Watson J. 2000). The efficiency parameter of the matching function m allows us to reproduce an average job finding rate for revealed workers which is close to the monthly transition rate from unemployment to employment observed in France in 2002 for the youth population: 12.44%. The exogenous destruction rate is fixed to the monthly transition rate from employment to unemployment observed for the same population: 2.92%. The calibration is reported in Table 2. As there are no quantitative estimates of non-severance dismissal costs, we rely on (Heckman J. and Pages C. 2000) who estimated that effective severance costs for European countries lie in the 1 to 4 month range. Thus, we simulate the model for a set of values of F between 0 and $4 * w_r^g$. According to the calibration, the threshold values of F are:

$$\bar{F}_1 = 1.62 * w_r^g \quad and \quad \bar{F}_2 = 3.24 * w_r^g$$

Table 1 displays the results for the segment where revealed workers are searching for a job. The labor contract is such that the expected gains from employment and unemployment are equal. The job finding rate for high-productive and low-productive workers are respectively 12.54% and 11.29%. The average unemployment duration under full information is about 8 months.

Table 1: Numerical exercise: Segment where revealed workers a re searching for a job

	G-type workers	B-type workers
Optimal wage contracts: w_r^j	0.95	0.855
Job finding rate, monthly (%): $p(\theta_R^i)$	12.54	11.29

25

Table 2: Computation

Parameters		Values	Targets
Discount factor	β	0.996	Yearly interest rate of 4%
Elasticity of the matching function with respect to unemployment	φ	0.5	(Petrongolo B. and Pissarides C. 2001)
Relative risk aversion	σ	2	Literature: $\sigma \in [1;3]$
High level of worker's ability	y^G	1	Normalization
Low level of worker's ability	y^B	0.9	Productivity gap: 10%; Arbitrary choice
Proportion of G-type entrants	ψ	0.75	Arbitrary choice
Unemployment income:	b	0.95	To ensure that $y^B < b^G$
	by^G	0.95	
	by^B	0.855	
Exogenous destruction rate	s	2.92%	Separation rate France 2002, [20-25] years-old workers.
Matching efficiency parameter	m	0.3	Job finding rate of revealed workers 12.44% France 2002, [20-25] years-old workers.
Cost of a vacancy	c	1.1	(Den Hann W.J. et al. 2000): $q(\theta) = 0.73$. c is fixed such that $q(\theta_R^i) \in [0.71;0.79]$

6.2 The case with a constant wage: Effects of the Employment Protection Legislation

We first consider the numerical results for the case with a constant wage. Table 3 reports the menu of contracts the firm can offer according to the strictness of the EPL while Table 4 summarizes the equilibrium results. The first column of Table 4 characterizes the economy under full information. The equilibrium unemployment rate reaches 19.88%, which is two points higher than the unemployment rate observed in France in 2002 for the youth population. One should notice that the probability for new entrants to find a job differs from the probabilities characterizing the experienced workers as it integrates externalities associated with non directed search. Another way to feature the labor market entry process under information asymmetry would be to consider that the firms not only designed a menu of separating contracts to new entrants, but also segment their search. The labor market entry will be characterized by two tightness values: θ_E^i for $i = \{G; B\}$. Recall that the paper does not investigate how to internalize search externalities.
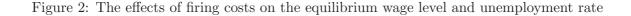
Table 3 reports the menu of contracts the firm can offer according to the level of firing costs. For $F < \bar{F}_1$, the firms offer a menu of contracts to new entrants that gives to high productive workers the wage offered under full information while B-type workers get a small information rent of 0.034%. The information asymmetry reduces the average expected profit of a job at the labor market entry, thereby reducing job creations. However, the Table 4 suggests that it barely affects the unemployment rate w.r.t the equilibrium under full information. The labor market is not affected by in increase in firing costs as long as the level is lower than $\bar{F}_1$: The EPL does not prevent firm from dismissing B-type mismatched workers while paying G-type workers at their reservation wage.
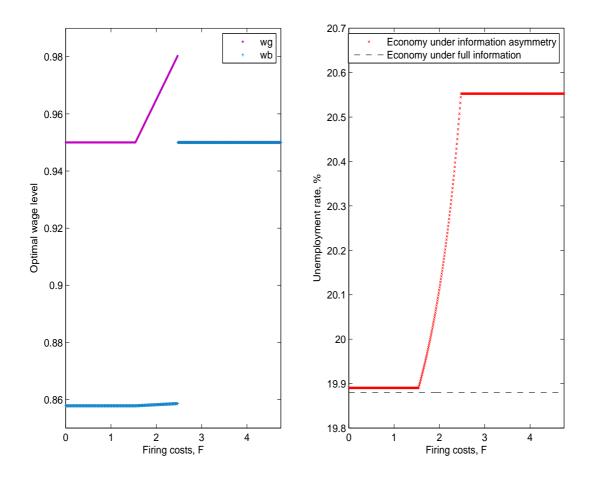
On the contrary, a higher level of firing costs distorts hiring practices and increases the unemployment rate. For the highest values of firing costs, $F > \bar{F}_2$, firms are unable to implement separating contracts. Indeed, the threshold $\hat{w}^g$ is higher than the highest level of the output y^G. In order to dismiss B-type mismatched workers, the firm would have to give a wage w_e^g such that the hiring of good workers is not profitable. The firm is constrained to offer a pooling contract that gives all workers the value of G-type workers' home production (b^G). B-type workers get an information rent of 1.05%, (Table 3).

Let us now consider the intermediate levels of the EPL: $\bar{F}_1 < F < \bar{F}_2$. The firm is able to implement a menu of contracts that elicits workers' private information by giving up some information rent to high-productive workers that turns out to be higher than the rent given to low-productive workers. In consequence, high-productive workers are better off with intermediate levels of the EPL, while low-productive workers are better off with a more stringent EPL, for which firms are not able to discriminate. Table 3 shows that the optimal wage increases with the level of firing costs. The surplus of the wage w_e^g strongly reduces the expected profit of a job $\Pi_e^{G,g}$ but allows the firm to dismiss a B-type mismatched worker. The threshold value of $\tilde{F}$ is about $2.6 * w_r^g$. The fifth column of table 3 illustrates that for $\tilde{F} < F < \bar{F}_2$, the increase in w_e^g the firm has to concede to induce B-type workers to choose to right contract would imply a reduction of the expected profit by 70% while implementing

Table 3: The menu of separating contracts at the LM entry: the case with a constant wage

Strictness of the EPL	No EPL	$F = w_r^g$	$F = 2w_r^g$	$F = 2.5w_r^g$	$F = 3w_r^g$	$F = 3.5w_r^g$	$F = 4w_r^g$
	0	0.95	1.9	2.37	2.85	3.32	3.8
$\bar{F}_1 = 1.538$; $\bar{F}_2 = 3.077$	$F < \bar{F}_1$	$F < \bar{F}_1$	$\bar{F}_1 < F < \bar{F}_2$	$\bar{F}_1 < F < \bar{F}_2$	$\bar{F}_1 < F < \bar{F}_2$	$F > \bar{F}_2$	$F > \bar{F}_2$
Threshold value $\tilde{F}$	2.484	2.484	2.481 $F < \tilde{F}$	2.477 $F < \tilde{F}$	2.473 $F > \tilde{F}$	2.469	2.465
Optimal wage contracts							
G-type entrants w_e^g	0.95	0.95	0.9618	0.9772	0.9926	0.95	0.95
B-type entrants w_e^b	0.8578	0.8578	0.8581	0.8585	0.8589	0.95	0.95
Threshold $\hat{w}^g$	0.9	0.9309	0.9618	0.9772	0.9926	1.008	1.0235
Dismissal of B-type shirkers	YES	YES	YES	YES	YES	NO	NO
Information rent, LM entry							
G-type entrants $V_e^{G,g}$	100	100	100.128	100.291	100.449	100	100
B-type entrants $V_e^{B,b}$	100.034	100.034	100.038	100.042	100.047	101.046	101.046
Base 100: economy under full information							
Expected profit Π_E First Best base 100	98.57	98.57	80.33	56.38	32.43	51.28	51.282

a pooling contract reduces the expected profit by only 50% w.r.t the economy under full information. The optimal contract under adverse selection is thus the pooling one. The economy reaches the same steady sate as for $F > \bar{F}_2$. New entrants spend in average 16 months before getting their first job and the unemployment rate of the economy increases by 0.7 points w.r.t the economy under full information, (Table 4). Finally, the figure 2 illustrates the profiles of the optimum wages offered to new entrants and of the aggregate unemployment rate according to the levels of firing costs.

Figure 2: The effects of firing costs on the equilibrium wage level and unemployment rate

Table 4: The labor market equilibrium: the case with a constant wage

Strictness of the EPL	Economy under full information	Economy under adverse selection					
		$F = 0$	$F = w_r^g$	$F = 2w_r^g$	$F = 2.5w_r^g$	$F = 3w_r^g$	$F = 4w_r^g$
Optimal wage contracts							
G-type entrants w_e^g	0.95	0.95	0.95	0.9618	0.9772	0.95	0.95
B-type entrants w_e^b	0.855	0.8578	0.8578	0.8581	0.8585	0.95	0.95
Probability to find a job,							
$p(\theta_E)$ monthly (%)	12.23	12.06	12.06	9.83	6.90	6.27	6.27
Unemployment rate (%)	19.88	19.89	19.89	20.05	20.43	20.55	20.55

6.3   The optimal wage profile: Effects of the labor market institutions

We solve numerically the computed model and provide some rough estimates of the optimal wage profiles designed by firms according to the EPL and to the minimum wage. Numerical results are reported in Table 5.

An increasing wage profile is found to be optimal for both types of workers. For low EPL, high productive workers are paid initially less than their marginal value while more at the second stage of employment, as in (Lazear E.P. 1981). However, in our framework as the output is constant, it does not induce worker's effort but prevents mismatch. The contract designed for low-productive workers is flatter. In order to elicit private information, the firm gives up an information rent in both stages of employment: $w_e^b > b^B$. The lowest values of F do not affect the equilibrium as firms remain able to dismiss mismatched workers, whatever the stage of employment. We observe that designing an upward sloping wage with tenure barely increases the expected profit Π_E w.r.t to the case where firms are constrained to offer a constant wage. As firing costs are low, firms do not have to implement incentive mechanisms. Then, for high levels of EPL that prevent firms from offering a menu of contracts, the pooling contract is the one that ensures G-type workers participation and gives a constant wage to all workers. The level of firing costs is such that firms will not be able to dismiss mismatched workers whatever the wage profile. In consequence, they offer a constant wage contract.
Intermediate values of firing costs reduce the possibility for the firm to punish mismatched workers. As expected, firms still offer an increasing wage to good workers but with a higher growth rate and a lower initial wage. It allows them to dismiss shirkers once evolution to stage 2 occurs and thus to reduce the bad worker's incentives to shirk even in presence of firing costs. The dismissal probability falls from 1 to λ_e^g. Then, an increase in firing costs from $2 * w_r^g$ to $2.5 * w_r^g$ affects the economy. The firms raise the wage growth for good workers but the dismissal probability is reduced from 0.25 to 0.13. The incentive for B-type workers to choose the contract designed for G-type workers increases with firing costs. However, for intermediate levels of EPL, the loss in the expected profit w.r.t the economy under full information remains lower than 5%, so that job creations and employment are slightly reduced. Recall that in the case with a constant wage, the loss in the expected profit reached 20 to 40%. Allowing for a time-varying wage increases firm's flexibility and gives room for implementing a self-selection mechanism.

Finally, Table 6 provides a quantitative illustration of the effects of a minimum wage on the optimal employment contract. The value of the minimum wage is fixed arbitrarily to 0.88. One can argue that this value is high. However, a minimum wage lower than $b^B = 0.855$ would not affect the economy. We choose a value $b^B < \bar{w} < b^G$. Recall that we fixed the unemployment income's level in order to ensures $b^G > y^B$, as we are interested in equilibrium in which the firm dismisses a mismatched worker for $F = 0$. It also results in high wages.

Table 5: The labor market equilibrium

	Economy under full information	Economy under adverse selection				
Strictness of the EPL		$F = 0$	$F = w_r^g$	$F = 2w_r^g$	$F = 2.5w_r^g$	$F = 4w_r^g$
Optimal wage contracts						
G-type entrants						
$w_{1,e}^g$	0.95	0.9456	0.9456	0.8539	0.8511	0.95
$w_{2,e}^g$	0.95	0.9528	0.9528	0.965	0.9789	0.95
λ_e^g	0	0.0544	0.0544	0.2456	0.13	0
Average duration before promotion (months)	0	18.3	18.3	4	7.5	0
wage growth rate (%)	0	0.67	0.67	13	15	0
B-type entrants						
$w_{1,e}^b$	0.855	0.8567	0.8567	0.8511	0.8478	0.95
$w_{2,e}^b$	0.855	0.8583	0.8583	0.8578	0.8589	0.95
λ_e^b	0	0.0517	0.0517	0.05	0.066	0
Average duration before promotion (months)	0	19.3	19.3	20	15	0
wage growth rate (%)	0	1.9	1.9	0.8	1.3	0
Dismissal probability of B-shirkers		1	1	0.2456	0.13	0
Expected profit Π_E	100	98.59	98.59	97.44	95.03	51.28
Probability to find a job, monthly (%)	12.23	12.06	12.06	11.92	11.62	6.05
Unemployment rate (%)	19.88	19.89	19.89	19.90	19.92	20.6

As $\bar{w} < b^G$, the minimum wage has no impact on the labor market equilibrium for high level of firing costs. The numerical results suggest that for low values of the EPL, it only affects the contract designed for bad workers without preventing firms from implementing a menu of contracts. As the expected profit from a job is reduced, firms post less vacancies at the labor market thereby increasing the unemployment rate. The minimum wage thus mainly affects an economy characterized by an intermediate levels of the EPL. The firm is no longer allowed to offer the optimal wage profile derived previously. For $F = 2 * w_r^g$, the incentives for B-type workers to choose the g-type contract increase as the dismissal probability falls from 0.25 to 0.167. In consequence, for $F = 2w_r^g$, the firm is still able to implement a menu of contracts but the pooling one is preferred.

7   Conclusion

This paper supports the idea that labor markets operate in an environment where adverse selection mainly appears at the labor market entry, thus making risky the hiring of new entrants. We investigate the problem of optimal design of employment contracts for an economy characterized by a strict regulation concerning firing costs and a high level of minimum wage. The theoretical and quantitative analysis highlighted two threshold values of firing costs. We established that low firing costs do not affect the economy while a strict EPL prevent firms from implementing a menu of contracts as a self-selection mechanism since firms will be enable to dismiss the shirkers. For intermediate levels of firing costs, the optimal contract is an upward sloping wage with tenure. Bad workers are not induced to shirk as if they do, they will be dismissed before gaining access to a higher wage. Firing costs reduces the dismissal probability thereby increasing the incentives to shirk. In this paper, we considered two types of workers differing in their abilities but producing a constant output. Contrary to the findings of (Lazear E.P. 1981), there are no incentives to design a wage according to job tenure under full information or in the absence of any labor market institutions. A time-varying wage is offered to prevent shirking in the presence of firing costs. We argue that a high level of minimum wage distorts designing practices only for the intermediate levels of firing costs by affecting the implementation of increasing wage profiles. The threshold value of the employment protection legislation above which firms are no longer able to implement a menu of contracts is reduced. Our numerical results suggest that the labor market institutions that characterized most of the European countries contribute to the time-consuming integration process of young workers. The average unemployment duration at the labor market entry could be doubled with minimum wages and high EPL. However, it slightly increases the aggregate unemployment rate.

Table 6: The labor market equilibrium with a minimum wage

$\bar{w} = 0.88$	Economy under full information	Economy under adverse selection				
Strictness of the EPL		$F=0$	$F=w_r^g$	$F=2w_r^g$	$F=2.5w_r^g$	$F=4w_r^g$
Optimal wage contracts						
G-type entrants						
$w_{1,e}^g$	0.95	0.9456	0.9456	0.8894	0.95	0.95
$w_{2,e}^g$	0.95	0.9528	0.9528	0.9633	0.95	0.95
λ_e^g	0	0.0544	0.0544	0.167	0	0
Average duration before promotion (months)	0	18.3	18.3	6	0	0
wage growth rate (%)	0	0.67	0.67	8.31	0	0
B-type entrants						
$w_{1,e}^b$	0.855	0.88	0.88	0.88	0.95	0.95
$w_{2,e}^b$	0.855	0.88	0.88	0.88	0.95	0.95
λ_e^b	0	0	0	0	0	0
Average duration before promotion (months)	0	0	0	0	0	0
wage growth rate (%)	0	0	0	0	0	0
Dismissal probability of *B*-shirkers		1	1	0.167	0	0
Expected profit Π_E	100	87.15	87.15	85.74	51.28	51.28
Probability to find a job, monthly (%)	12.23	10.66	10.66	10.49	6.05	6.05
Unemployment rate (%)	19.88	19.99	19.89	20.0	20.6	20.6

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8 Appendix

8.1 The full information segment: experienced workers

$$\max_{w_{1,r}^j; w_{2,r}^j, \lambda_r^j} \Pi_{1,r}^j$$

subject to the participation constraint

$$V_{1,r}^j \geq U_R^i$$

The Lagrangian is:

$$\mathcal{L} = \Pi_r^j + \mu(V_r^j - U_R^i)$$

with μ the multiplier associated with the participation constraint.

The initial expected profit of a job occupied by a i-type revealed worker satisfies:

$$\Pi_{1,r}^j = \frac{[1 - \beta(1-s)](y^i - w_{1,r}^j) + \beta(1-s)\lambda_r^j(y^i - w_{2,r}^j)}{[1 - \beta(1-s)][1 - \beta(1-s)(1 - \lambda_r^j)]}$$

It is a decreasing and linear function in both $w_{1,r}^j$ and $w_{2,r}^j$ while the function's properties w.r.t. the evolution rate λ_r^j depend on the wage profile:

$$\frac{\partial \Pi_{1,r}^j}{\partial \lambda_r^j} = \beta(1-s)\frac{w_{1,r}^j - w_{2,r}^j}{[1 - \beta(1-s)(1 - \lambda_r^j)]^2}$$

$$\frac{\partial^2 \Pi_{1,r}^j}{\partial^2 \lambda_r^j} = -2\beta(1-s)^2\frac{w_{1,r}^j - w_{2,r}^j}{[1 - \beta(1-s)(1 - \lambda_r^j)]^3}$$

For an increasing wage profile, the function is decreasing and convex in λ_r^j, while it is increasing and concave in λ_r^j for a decreasing wage profile.

The net gain from initial employment for a i-type revealed worker satisfies:

$$(V_{1,r}^j - U_R^i) = \frac{[1 - \beta(1-s)]\{u(w_{1,r}^j) - u(b^i)\} + \beta(1-s)\lambda_r^j\{u(w_{2,r}^j) - u(b^i)\}}{[1 - \beta(1-s) + \beta p(\theta_R^i)][1 - \beta(1-s)(1 - \lambda_r^j)]}$$

Given the properties of the utility function $u(.)$, the function $(V_{1,r}^j - U_R^i)$ is increasing and convex in both $w_{1,r}^j$ and $w_{2,r}^j$. For an increasing wage profile, the function is increasing and concave in λ_r^j, while it is decreasing and convex in λ_r^j for a decreasing wage profile:

$$\frac{\partial(V_{1,r}^j - U_R^i)}{\partial \lambda_r^j} = \frac{\beta(1-s)[1 - \beta(1-s)]}{[1 - \beta(1-s) + \beta p(\theta_R^i)]}\frac{u(w_{2,r}^j) - u(w_{1,r}^j)}{[1 - \beta(1-s)(1 - \lambda_r^j)]^2}$$

$$\frac{\partial^2(V_{1,r}^j - U_R^i)}{\partial^2 \lambda_r^j} = -2\frac{\beta(1-s)^2[1 - \beta(1-s)]}{[1 - \beta(1-s) + \beta p(\theta_R^i)]}\frac{u(w_{2,r}^j) - u(w_{1,r}^j)}{[1 - \beta(1-s)(1 - \lambda_r^j)]^3}$$

The first-order necessary optimality conditions of the firm's problem are given by:

1) $\dfrac{\partial \mathcal{L}}{\partial w_{1,r}^j} = 0 \implies u'^i_{w_{1,r}^j} = \dfrac{1 - \beta\left[1 - s + p(\theta_R^i)\right]}{\mu[1 - \beta(1 - s)]}$

2) $\dfrac{\partial \mathcal{L}}{\partial w_{2,r}^j} = 0 \implies u'^i_{w_{2,r}^j} = \dfrac{1 - \beta\left[1 - s + p(\theta_R^i)\right]}{\mu[1 - \beta(1 - s)]}$

3) $\dfrac{\partial \mathcal{L}}{\partial \lambda_r^j} = 0 \implies (w_{1,r}^j - w_{2,r}^j) = \mu \dfrac{[1 - \beta(1 - s)]}{1 - \beta\left[1 - s + p(\theta_R^i)\right]}\left\{u(w_{1,r}^j) - u(w_{2,r}^j)\right\}$

4) $\mu\left[V_{1,r}^i - U^{i;R}\right] = 0$

According to the two first conditions, $u'(w_{1,r}^j) = u'(w_{2,r}^j)$ implying that $w_{1,r}^j = w_{2,r}^j$. The optimal contract is thus defined by a single value w_r^j.
As $\mu \neq 0$, the participation constraint is saturated so that $u(w_r^j) = u(b^i)$. The optimal contract gives the worker a wage that equals his unemployment income: $w_r^j = b^i$.

8.2 The segment with adverse selection: new entrants. The case with a constant wage

$$\max_{w_e^g, w_e^b} \Pi_E = \left\{\psi \Pi_e^{G,g} + (1 - \psi)\Pi_e^{B,b}\right\}$$

subject to the participation constraints

$$V_e^{G,g} \geq U_R^G \qquad\qquad (PC_G)$$
$$V_e^{B,b} \geq U_R^B \qquad\qquad (PC_B)$$

and to the adverse selection incentive constraints

$$V_e^{G,g} \geq V_e^{G,b} \qquad\qquad (IC_G)$$
$$V_e^{B,g} \geq V_e^{B,g} \qquad\qquad (IC_B)$$

The expected profit of a job occupied by a new entrant is a weighted average of $\Pi_e^{i,j}$ and satisfies:

$$\Pi_E = \psi \frac{y^G - w_e^g}{1 - \beta(1 - s)} + (1 - \psi)\frac{y^B - w_e^b}{1 - \beta(1 - s)}$$

It is thus linear and decreasing in both wages w_e^g and w_e^b.

As demonstrated previously, the optimal contract for revealed workers is such that $V_r^j = U_R^i$ for $i = j$, which implies $(1 - \beta)U_R^i = u(b^i)$. Using this result and equation (25), the net gain from employment to workers who chose the right contract satisfies:

$$(V_e^{i,j} - U_R^i) = \frac{u(w_e^j) - u(b^i)}{[1 - \beta(1 - s)]} \quad for \quad i = j$$

Given the properties of the utility function $u(.)$, $(V_e^{i,j} - U_R^i)$ is increasing and concave in w_e^j.

The net gain from choosing the right contract to G-type worker is given by:

$$(V_e^{G,g} - V_e^{G,b}) = \frac{u(w_e^g) - u(w_e^b)}{[1 - \beta(1 - s)]}$$

Given the properties of the utility function $u(.)$, $(V_e^{G,g} - V_e^{G,b})$ is increasing and concave in w_e^g while decreasing and convex in w_e^b.

Finally, the net gain from choosing the right contract to B-type worker differs according to the firm's separation decision:

$$(V_e^{B,b} - V_e^{B,g}) = \frac{u(w_e^b) - u(w_e^g) + \beta(1 - s)[u(w_e^g) - u(b^B)]}{[1 - \beta(1 - s)]}$$

if B-type mismatched workers are dismissed, and:

$$(V_e^{B,b} - V_e^{B,g}) = \frac{u(w_e^b) - u(w_e^g)}{[1 - \beta(1 - s)]}$$

if B-type mismatched workers are retained. Given the properties of the utility function $u(.)$, $(V_e^{B,b} - V_e^{B,g})$ is increasing and concave in w_e^b while decreasing and convex in w_e^g, whatever the firm's separation decision.
We now solve the firm's problem for the two cases.

8.2.1 The case where B-type mismatched workers are retained once revealed

This case emerges for $F > \frac{y^G - y^B}{[1 - \beta(1-s)]}$ as firms are not able to set a wage $w_e^g > \hat{w}^g$. Indeed, it would imply $w_e^g > y^G$. We use the expression of $(V_e^{B,b} - V_e^{B,g})$ that integrates job continuation.

The firm's problem is the one stated above. The Lagrangian is given by:

$$\mathcal{L} = \Pi_E + \mu_1(V_e^{G,g} - U_R^G) + \mu_2(V_e^{B,b} - U_R^B) + \mu_3(V_e^{G,g} - V_e^{G,b}) + \mu_4(V_e^{B,b} - V_e^{B,g})$$

with μ_1 and μ_2 the multipliers associated with the participation constraints and with μ_3 and μ_4 the multipliers associated with the incentive constraints for respectively G-type and B-type workers.

The first-order necessary optimality conditions are given by:

$$1) \quad \frac{\partial \mathcal{L}}{\partial w_e^g} = 0 \quad \implies \quad u'_{w_e^g} = \frac{\psi}{\left\{ \mu_1 + \mu_3 - \mu_4[1 - \beta(1-s)] \right\}}$$

$$2) \quad \frac{\partial \mathcal{L}}{\partial w_e^b} = 0 \quad \implies \quad u'_{w_e^b} = \frac{(1-\psi)}{\left\{ \mu_2 - \mu_3 + \mu_4 \right\}}$$

$$3) \quad \mu_1 \left\{ \frac{u(w_e^g) - u(b^G)}{[1 - \beta(1-s)]} \right\} = 0$$

$$4) \quad \mu_2 \left\{ \frac{u(w_e^b) - u(b^B)}{[1 - \beta(1-s)]} \right\} = 0$$

$$5) \quad \mu_3 \left\{ \frac{u(w_e^g) - u(w_e^b)}{[1 - \beta(1-s)]} \right\} = 0$$

$$6) \quad \mu_4 \left\{ \frac{u(w_e^b) - u(w_e^g)}{[1 - \beta(1-s)]} \right\} = 0$$

It is straightforward that the incentive constraints are saturated: $u(w_e^g) - u(w_e^b) \geq 0$ and $u(w_e^b) - u(w_e^g) \geq 0$ implies $u(w_e^g) = u(w_e^b)$.

The optimal contract is thus a single value w_e. Given that $b^G > b^B$, the participation constraint for B-type workers cannot be saturated in order to ensure the participation of G-type workers: $w_e \geq b^G > b^B$. Finally, as the expected profit is decreasing in w_e^j, the first constraint will be saturated: $w_e = b^G$.

8.2.2 The case where B-type mismatched workers are laid off once revealed

In order to be able to dismiss B-type mismatched workers, the firm has to offer a wage w_e^g higher than the threshold value $\hat{w}^g = y^B + [1 - \beta(1 - s)]F$. This dismissal constraint is added to the firm's problem now given by:

$$\max_{w_e^g, w_e^b} \Pi_E = \left\{ \psi \Pi_e^{G,g} + (1 - \psi)\Pi_e^{B,b} \right\}$$

subject to the participation constraints

$$V_e^{G,g} \geq U_R^G \qquad (PC_G)$$
$$V_e^{B,b} \geq U_R^B \qquad (PC_B)$$

to the adverse selection incentive constraints

$$V_e^{G,g} \geq V_e^{G,b} \qquad (IC_G)$$
$$V_e^{B,g} \geq V_e^{B,g} \qquad (IC_B)$$

and to the dismissal constraint

$$w_e^g \geq \bar{w}_e^g \qquad (DC)$$

The Lagrangian is written as:

$$\mathcal{L} = \Pi_E + \mu_1(V_e^{G,g} - U_R^G) + \mu_2(V_e^{B,b} - U_R^B) + \mu_3(V_e^{G,g} - V_e^{G,b}) + \mu_4(V_e^{B,b} - V_e^{B,g})$$
$$+ \mu_5\big(w_e^g - y^B + [1 - \beta(1 - s)]F\big)$$

with μ_1, μ_2, μ_3 and μ_4 the multipliers associated with the participation and incentive constraints, for respectively G-type and B-type workers, and with μ_5 the multiplier associated with the dismissal constraint.

The first-order necessary optimality conditions are given by:

$$1) \quad \frac{\partial \mathcal{L}}{\partial w_e^g} = 0 \quad \implies \quad u'_{w_e^g} = \frac{\psi - \mu_5}{\left\{\mu_1 + \mu_3 - \mu_4[1 - \beta(1 - s)]\right\}}$$

$$2) \quad \frac{\partial \mathcal{L}}{\partial w_e^b} = 0 \quad \implies \quad u'_{w_e^b} = \frac{(1 - \psi)}{\left\{\mu_2 - \mu_3 + \mu_4\right\}}$$

$$3) \quad \mu_1 \left\{ \frac{u(w_e^g) - u(b^G)}{[1 - \beta(1 - s)]} \right\} = 0$$

$$4) \quad \mu_2 \left\{ \frac{u(w_e^b) - u(b^B)}{[1 - \beta(1 - s)]} \right\} = 0$$

$$5) \quad \mu_3 \left\{ \frac{u(w_e^g) - u(w_e^b)}{[1 - \beta(1 - s)]} \right\} = 0$$

$$6) \quad \mu_4 \left\{ \frac{u(w_e^b) - u(w_e^g) + \beta(1 - s)[u(w_e^g) - u(b^B)]}{[1 - \beta(1 - s)]} \right\} = 0$$

$$7) \quad \mu_5 \left\{ w_e^g - y^B - [1 - \beta(1 - s)]F \right\} = 0$$

We first demonstrate that the constraints (PC_B) and (IC_G) cannot be saturated:

- **The participation constraint of B-type workers (PC_B) cannot be saturated.**
  If the constraint (PC_B) is saturated, (IC_G) cannot be. Indeed, according to (PC_G), $u(w_e^g) - u(b^G) \geq 0 \implies u(w_e^g) - u(b^B) > 0$. The saturation of (PC_B) entails $u(w_e^b) = u(b^B)$ so that $u(w_e^g) - u(w_e^b) > 0$. Thus (IC_G) is not saturated:$u(w_e^g) - u(w_e^b) > 0$
  As (PC_B) is assumed to be saturated, the following equality does hold:

  $$u(w_e^b) - u(w_e^g) + \beta(1 - s)[u(w_e^g) - u(b^B)] = [1 - \beta(1 - s)][u(w_e^b) - u(w_e^g)] < 0$$

  As a result, the last optimality condition is not verified and B-type workers are induced to choose the contract designed for G-type workers: $V_e^{B,b} - V_e^{B,g} < 0$.

- **The incentive constraint for G-type workers (IC_G) cannot be saturated if (PC_B) is not** We demonstrated that (PC_B) is not saturated thus yielding $\mu_2 = 0$. If the constraint (IC_G)

is saturated, the optimal wage will be a single value, $u(w_e^g) = u(w_e^b)$, such that $u(w_e^b) > u(b^B)$. According to the second optimality condition:

$$\mu_4 = \frac{(1-\psi)}{u'(w_e^b)} + \mu_3 > 0$$

The incentive constraint (IC_B) should be saturated thus implying

$$u(w_e^b) - u(w_e^g) = -\beta(1-s)[u(w_e^g) - u(b^B)]$$

However the left term has null value since (IC_G) is assumed to be saturated while the right term is strictly negative since (PC_B) is not.

In consequence, the constraints (PC_B) and (IC_G) cannot be saturated:

$$V_e^{B,b} > U_r^B \quad and \quad V_e^{G,g} > V_e^{G,b}$$

As $\mu_2 = \mu_3 = 0$, the second optimality condition can be rewritten as

$$u'_{w_e^b} = \frac{(1-\psi)}{\mu_4} \quad \Longrightarrow \quad \mu_4 > 0$$

The constraint (IC_B) is saturated so that $V_e^{B,b} = V_e^{B,g}$. The first optimality condition can be rewritten as

$$\mu_1 = \frac{\psi - \mu_5}{u'(w_e^g)} + [1 - \beta(1-s)]\mu_4 > 0$$

We now distinguish two cases according to the saturation of (DC).

1. **Assume first that the dismissal constraint in not saturated**: $\mu_5 = 0$.
   In consequence, **the constraint (PC_G) is saturated**: $V_e^{G,g} = U_r^G$.

   The optimal menu of contracts satisfies:

   $$\begin{aligned}
   u(w_e^g) = u(b^G) \quad &\Longrightarrow \quad w_e^g = b^G \\
   u(w_e^b) > u(b^B) \quad &\Longrightarrow \quad w_e^b > b^B \\
   u(w_e^g) = u(w_e^b) \quad &\Longrightarrow \quad w_e^g > w_e^b \\
   u(w_e^b) = u(w_e^g) - \beta(1-s)[u(w_e^g) - u(b^B)] \\
   w_e^g > y^B + [1 - \beta(1-s)]F
   \end{aligned}$$

   According to (DC), this case emerges for $b^g > y^B + [1 - \beta(1-s)]F$.

2. **Assume now that the dismissal constraint in saturated**:

For $b^g \leq y^B + [1 - \beta(1 - s)]F$, the optimal wage satisfies $w_e^g = \bar{w}_e^g$.

The constraint (PC_G) is not saturated: $V_e^{G,g} > U_r^G$.

The optimal menu of contracts satisfies:

$$
\begin{aligned}
u(w_e^g) > u(b^G) &\implies w_e^g > b^G \\
u(w_e^b) > u(b^B) &\implies w_e^b > b^B \\
u(w_e^g) = u(w_e^b) &\implies w_e^g > w_e^b \\
u(w_e^b) = u(w_e^g) - \beta(1 - s)[u(w_e^g) - u(b^B)] \\
w_e^g = y^B + [1 - \beta(1 - s)]F
\end{aligned}
$$

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