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Auteurs

Anne Bucher, Sébastien Ménard

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Faculté des sciences économiques et de gestion
Pôle européen de gestion et d'économie (PEGE)
61 avenue de la Forêt Noire
F-67085 Strasbourg Cedex

Secrétariat du BETA
Géraldine Del Fabbro
Tél. : (33) 03 68 85 20 69
Fax : (33) 03 68 85 20 70
g.delfabbro @unistra.fr
www.beta-umr7522.fr

The effects of firing costs on the wage contracts under adverse selection

Anne Bucher[1] and Sébastien Ménard[2]

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Abstract

We develop a two-period principal-agent model to investigate the effects of firing costs on self-selection mechanisms and on the optimal wage contracts under adverse selection. There are two types of risk-averse workers who differ by their ability. The worker's ability is private information but revealed once engaged in production. The adverse selection problem may be solve by workers' selection from a menu of separating contracts that specifies a sequence of wages with dismissal being the only form of punishment to a worker who overstated his ability. We find that as firing costs increase, the wage-tenure profile of high-ability workers gets steeper while the information rent left to low-ability workers vanishes. For higher levels of firing costs, an incentive menu of contracts provides the most able workers with a lower starting wage than the less able workers. As the expected profit from separating contracts decreases with dismissal costs, there exists a threshold above which the employer prefers to offer a pooling wage that might drive *good* workers out of the labor market.

Keywords: Adverse Selection, Principal Agent, Labor Contracts, Wage, Firing Costs

JEL: D82 ; J31 ; J41 ; J08

[1]A.Bucher: BETA, Université de Strasbourg, Institut du Travail, 39 avenue de la Forêt Noire, 67000 Strasbourg, France- +33 (0)3 68 85 83 16 - e-mail: anne.bucher@unistra.fr

[2]S. Ménard: GAINS-TEPP, Université du Maine, Faculté de Droit et de Sciences Économiques, Avenue Olivier Messiaen, 72085 Le Mans Cedex 9, France - +33(0)2 43 83 27 97 - e-mail: sebastien.menard@univ-lemans.fr

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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. Adverse selection arises when workers have private information about their productivity, trainability or preferences, and hiring a worker becomes risky as less desirable workers have an incentive to overstate their qualifications. It is well established in incentives and contract theories that the adverse selection problem may be solve by self selection mechanisms. On the labor market, firms might be induced to offer separating employment contracts with promotion and dismissal as self-selection devices in order to reveal workers' abilities: while high-productive workers would benefit from a salary increase once detected, low-productive workers who overstated their abilities might be dismissed. Dismissal is a form of punishment to a shirker that ensures incentive compatibility of separating contracts but it works as a self selection mechanism as long as it remains a credible threat, which depends on the strictness of the employment protection legislation that characterizes the economy.
This paper proposes a principal-agent model to analyze the role of firing costs in self-selection mechanisms. The effects of firing costs have mainly been investigated from a macroeconomic perspective. A bulk of the literature focuses on the impact on aggregate employment and labor market flows[3] while the impact on firms' compensation and salary practices remains to be explored. It is well known that employers are induced to offer employment separating contracts under adverse selection. Lazear E. (2000) already pointed out that performance-based pay can be used as self selection contracts to attract more able workers, which was confirmed by the empirical analysis of Oyer P. & Schaefer S. (2005). Our main contribution is therefore to analyze how the regulation concerning firing costs affects the optimal design of wage contracts under adverse selection or prevent firms from implementing self-selection mechanisms.

We develop a two-period principal-agent model in which the employer delegates the production of an output to a risk-averse worker through a take-it-or-leave-it wage contract offer. There are two types of workers: *good* and *bad* workers have private information about their abilities which would be inferred by the employer from the output performance. The signaling theory, as initially developed by Spence M. (1973), argues that education can be used as a signal of workers abilities to the firm thereby narrowing the informational gap. However, workers may still be unequally productive in employment within the same qualification level and information asymmetry remains when workers with different abilities apply for a given job. A large literature now exists and provides some empirical evidence on employers learning about workers skills and abilities (see for instance[4] Farber H. & Gibbons R. (1996)). In order to reveal workers abilities prior hiring, we assume that the employer offers a menu of separating contracts that specifies a sequence of wages with dismissal being the punishment to a shirker.
Not surprisingly, we show that a pair of fully separating contracts provides each *good* worker with a rising wage-tenure profile while each *bad* worker receive a constant wage. One should notice that Hagedorn M. et al. (2010) found similar results when deriving the optimal unemployment benefits profile under adverse selection: decreasing benefits are designed to *good* job seekers while the optimal profile designed for *bad* job seekers is flatter. In our framework, the starting wage offered to *good* workers has to be low enough in order to discourage *bad* workers

[3]See for instance Blanchard O. & Wolfers J. (2000), Blanchard O. & Portugal P. (2001) and Bassanini A. & Garnero A. (2013) for empirical evidence and Bentolila S. & Bertola G. (1990), Bertola G. (1990), Hopenhayn H. & Rogerson R. (1993), Garibaldi P. (1998), Mortensen D. & Pissarides C. (1999) and Pries M. & Rogerson R. (2005) for theoretical analysis.

[4]Farber H. & Gibbons R. (1996) use longitudinal data and find that the influence of abilities on wage increases with workers' experience suggesting an important role for employer learning. Most recent papers attempt to determine whether or not employer learning is private or the speed of employer learning (see Lange F. (2007), Schoenberg U. (2007), Schweri J. & Mueller B. (2008) and Kahn L. (2013)).

from shirking. Then, the second-period wage has to be high enough to ensure both that *good* workers accept the contract offer and that dismissal of a shirker constitutes a credible threat by remaining optimal. However, since workers are risk-averse, a steeper wage-tenure profile that provides the same expected utility to the worker costs more to the firm. We thus find two candidate solutions to the adverse selection problem for low levels of firing costs: the employer faces a trade off between giving up an information rent to *bad* workers or reducing the starting wage offered to *good* workers in order to prevent shirking.
Our main finding is that the level of firing costs strongly affects the optimal design of wage contracts. As the dismissal costs increase, the wage-tenure profile of *good* workers gets steeper (lower starting wage with higher salary increase) while the information rent left to the bad workers vanishes (if initially positive) such that, at some point, the wage received by each *bad* worker exceeds the starting wage of each *good* worker. Besides, the expected profit from a menu of separating contracts decreases with the level of firing costs. We show that there is a threshold above which the employer prefers to offer a pooling wage that might drives *good* workers out of the labor market. We perform numerical exercises to deepen the analysis on the conditions under which a pooling equilibrium emerges. The threshold of firing costs above which a pooling wage is preferred increases with the ability gap but decreases with the strength of risk-aversion and with the proportion of good workers as soon as it ensures that *good* workers participate in a pooling equilibrium. Finally, a sensitivity analysis suggests that a self-selection mechanism with dismissal as the only form of punishment to a shirker is optimal if the level of employment protection that characterizes the economy is low enough. When the regulation is stronger, the employers might be induced to freeze salaries of shirkers rather than to fire them in order to remain able to implement separating contracts.

Our paper relates to the literature on both employment protection legislation and labor market implications of adverse selection. Most of the papers that investigate the effects of firing costs mainly focuse on the impact on employment, labor market flows, growth and innovation[5]. Regarding the potential effects on wages, models with labor market frictions and decentralized bargaining predict that firing costs reduce the entry wage (see[6] Pissarides C. (2000)) while models that account for investment in specific human capital suggest that firing costs increase the wage-tenure profile by raising workers' productivity (see Wasmer E. (2006)). The previous work of Bertola G. (1990) on aggregate data suggested that firing costs tend to reduce wages. More recent papers explore the effects on workers' individual wages as Leonardi M. & Pica G. (2013) who find that the effects differ according to the job tenure and the wage distribution, suggesting that it depends on workers' and firms' relative bargaining power. Our paper differs from the existing literature on employment protection legislation as we focus on the effects on the optimal design of wage contracts and self-selection mechanisms under adverse selection. Kugler A. & Saint-Paul G. (2004) also analyze the effects of firing costs under adverse selection but focus on the impact on firms' hiring practices. They show that job-to-job transitions increase with firing costs as firms prefer to hire employed workers who are less likely to be lemons.
Economists have concerned themselves with the optimal employment contract with incomplete information since the seminal papers of Lazear E.P. (1981) and Shapiro C. & Stiglitz J.E. (1984). The optimal wage dynamics arose as the empirical evidence has suggested for many years that the wage increases with job tenure for a given productivity. The theoretical literature had already provided some explanations: Salop J. & Salop S. (1976) argued that firms discourage individuals characterized by a high propensity to quit the job by increasing the wage with job tenure while Harris M. & Holmstrom B. (1982) suggested that the optimal wage profile is increasing as both firms and workers gradually learn about workers' ability by observing the output produced over

[5]See Griffith R. & Macartney G. (2014) for an empirical evidence on the effects of EPL on innovation.

[6]In a matching framework *à la* Mortensen-Pissarides, the effects of firing costs on the wage depend on the worker's bargaining power and on his ability to force renegotiation. If renegotiation takes place, the starting wage is initially lower but increases after renegotiation as the worker is rewarded for the saving for firing costs.

time. In our framework, a rising wage-tenure profile associated with dismissal of shirkers ensures workers' self-selection from the menu of contracts. Some recent papers investigate the interaction between search frictions and adverse selection. Guerrieri V. et al. (2009) extend 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 and pooling contracts will not increase firms' profit. More closely related to our work, the paper of Carillo-Tudela C. & Kaas L. (2011) develops an equilibrium job search model and points out that low-wage firms offer separating contracts and hire all types of workers in equilibrium, whereas pooling contracts are offered by high-wage firms to retain high-ability workers. Their contribution is thus to analyze the implications on worker turnover and wage dynamics while we focus on the interaction with the regulation concerning firing costs.

The paper proceeds as follows. In the next section we describe the model. Section 3 presents the optimal menu of separating contracts, the pooling equilibrium and discuss under which conditions a menu of contracts is preferred to a pooling wage. In section 4 we solve numerical exercises to investigate quantitatively how firing costs affect the optimal wage contracts and provide sensitivity analysis.

2 The model

2.1 The environment

All agents are forward-looking and have a common discount factor β. We consider a principal-agent model with two discrete-time periods: $t = \{0; 1\}$. An employer delegates the production of an output for both periods to a worker through a take-it-or-leave-it wage contract offer w_t. The output produced by a worker depends on his innate ability which is private information. However, the employer infers the employed worker's ability from the output performance at the end of the first period.

There are two types of workers: a fraction ψ has high ability, a^G, while a fraction $(1-\psi)$ has low ability, $a^B < a^G$. For the rest of the analysis, we will refer to workers with ability a^B and a^G as respectively *bad* and *good* workers. Employed workers with ability a^i generate an output flow $y^i = y \cdot a^i$ for $i = \{B; G\}$. There are no productivity shocks so that a *good* worker (resp. a *bad* worker) remains *good* (resp. *bad*). We do not consider the workers' effort but implicitly assume that whatever their effort, some workers are less productive than others. This eliminates all moral-hazard issues. The decision facing workers is whether to work or to remain inactive. This choice depends on the wage contract the firm offers and on the worker's outside option. As inactive, workers enjoy some real return $h^i = h \cdot a^i$, with $h < y$, that integrates returns from home production, unemployment or leisure activities. The main point is that the worker's reservation utility depends on his ability. Consequently, *good* workers are more selective in accepting wage offers than *bad* workers and under asymmetric information *bad* workers are induced to misreport their type in order to receive a higher wage offer. As developed by Weiss A. (1980), adverse selection arises since workers' ability and reservation utilities are positively correlated[7].

The employer has to offer a menu of contracts to separate the worker types and solve the adverse selection problem. When contracts are optimally designed, private information is elicited by workers' self selection. We denote by $j = \{b; g\}$ the contract designed by the employer for respectively *bad* and *good* workers. A separating contract consists in a sequence of wages $\{w_0^j, w_1^j\}$ and a firing policy. At the end of period 0, the starting wage w_0^j is paid ; the employer observes

[7]If we assume that all inactive workers get h, *bad* workers have no incentive to shirk and the optimal wage contract is a pooling wage that provides each worker with their expected reservation utility. Besides, empirical evidence suggests that reservation wages are indeed positively correlated with observed attributes of ability as the level of education (see for instance Prasad E. (2003) and Blien U. et al. (2012)).

the output flow and learns about the worker's ability[8]. A worker who truthfully reported his ability is retained. Production is carried out and transfer w_1^j is paid. On the contrary, a worker who is caught shirking might be laid off at the beginning of period 1. Dismissal has to be optimal from the firm's point of view in order to be a credible threat to workers. It is straightforward that retaining a *good* shirker[9] provides a higher profit than expected (since $y^G > y^B$) so that only *bad* shirker will be dismissed. In our framework, we assume that dismissal is the only possible form of punishment to a shirker. It requires the payment of firing costs, F. The level of firing costs thus affects the menu's incentive-compatibility and determines both the conditions under which a menu of separating contracts can be used and the optimal design of separating contracts. An alternative would be to allow the firm to cut the wage of misreporting workers ; this alternative is discussed in section 4.

To complete the description of the model, we state the preferences. The firm is risk-neutral while workers are risk-averse with preferences:

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

where c_t denotes the consumption. 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 standard, the function u is increasing and concave. There are no savings so that employees consume their labor income w while inactive workers consume the real return h^i. A i-type worker who rejects both contracts gets expected utility U^i. Let $\Pi^{i,j}$ be the expected profits to a firm from a worker with ability a^i who committed to contract j and $V^{i,j}$ the expected gains of contract j to a worker with ability a^i. These values satisfy:

$$\Pi^{i,j} = y^i - w_0^j + \beta(1-\phi_j^i)(y^i - w_1^j) - \beta\phi_j^i F \tag{3}$$

$$V^{i,j} = u(w_0^j) + \beta(1-\phi_j^i)u(w_1^j) + \beta\phi_j^i u(h^i) \tag{4}$$

$$U^i = u(h^i) + \beta u(h^i) \tag{5}$$

with $\phi_g^B = 1$ (*bad* shirkers are laid off), otherwise $\phi_j^i = 0$.

2.2 The separating equilibrium

The optimal menu of separating contracts solves the program:

$$\max_{w_0^j;w_1^j} \Pi_s = \psi\Pi^{G,g} + (1-\psi)\Pi^{B,b} = \sum_{t=0}^{1} \beta^t \left\{ \psi(y^G - w_t^g) + (1-\psi)(y^B - w_t^b) \right\}$$

[8]We do not consider any monitoring costs so that once engaged in production the employer perfectly screens the worker's ability.Introducing a monitoring technology as in Shapiro C. & Stiglitz J.E. (1984) and Carillo-Tudela C. & Kaas L. (2011) will complicate the model without modifying the main results drawn by our analysis.

[9]One should notice that *good* workers do not have any incentive to misreport their type. However, to solve the problem we consider the possibility that a *good* worker engages in contract b.

subject to the participation constraints

$$
\begin{aligned}
& V^{G,g} \geq U^G && (PC_G)\\
\Leftrightarrow \quad & u(w_0^g) + \beta u(w_1^g) - (1+\beta)u(h^G) \geq 0
\end{aligned}
$$

$$
\begin{aligned}
& V^{B,b} \geq U^B && (PC_B)\\
\Leftrightarrow \quad & u(w_0^b) + \beta u(w_1^b) - (1+\beta)u(h^B) \geq 0
\end{aligned}
$$

to the adverse selection incentive constraints

$$
\begin{aligned}
& V^{G,g} \geq V^{G,b} && (IC_G)\\
\Leftrightarrow \quad & u(w_0^g) + \beta u(w_1^g) - u(w_0^b) - \beta u(w_1^b) \geq 0
\end{aligned}
$$

$$
\begin{aligned}
& V^{B,b} \geq V^{B,g} && (IC_B)\\
\Leftrightarrow \quad & u(w_0^b) + \beta u(w_1^b) - u(w_0^g) - \beta u(h^B) \geq 0
\end{aligned}
$$

and to the dismissal constraint

$$
\begin{aligned}
& \Pi^{B;g}_{\phi_g^B=1} \geq \Pi^{B;g}_{\phi_g^B=0} && (DC)\\
\Leftrightarrow \quad & [y^B - w_0^g - \beta F] - [y^B - w_0^g + \beta(y^B - w_1^g)] \geq 0
\end{aligned}
$$

The employer maximizes a weighted average of the expected profits from a *good* and a *bad* worker, with ψ being the probability to meet a *good* worker. The participation constraints impose that each worker receives at least his expected reservation utility, U^i. Then, the employer has to guarantee incentive compatibility due to adverse selection i.e he has to ensure that only workers who truly possess the abilities they claim to possess would accept the offer. The last constraint ensures that the dismissal of a *bad* shirker is optimal: the expected profit from a laid-off worker (for $\phi_g^B = 1$) has to be higher than the expected profit from a non-laid off worker (for $\phi_g^B = 0$). If not, the firing threat would not be credible. *Bad* workers would anticipate that they would be retained even if they misreport their type. A menu of contracts would not be fully separating so that the employer would offer a pooling contract[10].

The optimization problem is solved in appendix A.1. We first find that a pair of fully separating contracts contains a contract b that offers a constant wage profile and a contract g that offers a rising wage-tenure profile and provides each *good* worker with his expected reservation utility:

$$w_0^b = w_1^b \equiv w^b \tag{6}$$

and

$$u(w_0^g) + \beta u(w_1^g) = (1+\beta)u(h^G) \qquad with \qquad w_0^g < h^G < w_1^g \tag{7}$$

This result is quite intuitive. Risk-aversion implies that workers prefer a smooth earnings profile. Thus, a constant wage profile is less costly to the firm than a rising wage profile that provides the same expected utility to the worker. There are no incentives to offer a contract b with a non-monotone wage while incentive-compatibility requires a rising wage-tenure profile of contract g. The starting wage offer has to be low enough to discourage *bad* workers from choosing contract g ($V^{B;g}$ increases with w_0^g) and the second-period wage w_1^g has to be high enough to ensure the

[10]The demonstration is available upon request.

good workers' participation. As standard, the *good* agents' participation constraint PC_G binds at the optimum.

Then, we find several candidate solutions to the adverse selection problem depending on the set of parameters. Let us start the analysis by assuming that $F = 0$ and then investigate the effects of firing costs. Figure 1 summarizes the results.

2.2.1 In the absence of firing costs, $F = 0$

The last constraint DC imposes $(w_1^g - y^B) \geq F$ to ensure that the dismissal of a *bad* shirker is an optimal decision. The second-period wage offer has to be high enough so that the level of firing costs does not exceed the expected net loss of retaining a *bad* shirker. For $F = 0$, the dismissal constraint becomes $w_1^g \geq y^B$. As we found $w_1^g > h^G$, assuming $h^G \geq y^B$ ensures the optimality of dismissal in the absence of firing costs (DC is non-binding). We set $h^G \geq y^B$ for the rest of the analysis. Note that this condition[11] is sufficient but not necessary as illustrated by the numerical exercises.

Firstly, we find that in the absence of firing costs, IC_B always binds. Since workers are risk averse, the optimal contract g is the flatter one that ensures incentive-compatibility. The starting wage offers thus satisfy:

$$u(w_0^g) = u(w^b) + \beta\{u(w^b) - u(h^B)\} \quad for\ F = 0 \tag{8}$$

Then, we find two candidate solutions to the adverse selection problem depending on whether or not the participation constraint of *bad* workers is binding ($w^b \geq h^B$). The two menus, described as follows, differ by both the wage tenure profile of contract g (resp. flat or steep) and the level of the information rent left to *bad* workers (resp. positive or null).

M_1 The starting wage offers are such that $h^B < w^b < w_0^g$ and the contract g provides each *good* worker with a slight salary increase.

M_2 The starting wage offers of both contracts are $w^b = w_0^g = h^B$ and the contract g provides each *good* worker with a high salary increase, such that:

$$w_1^g = \left\{ \frac{1+\beta}{\beta}(h^G)^{1-\sigma} - \frac{1}{\beta}(h^B)^{1-\sigma} \right\}^{\frac{1}{1-\sigma}} \equiv \chi \tag{9}$$

The first menu corresponds to the standard result of the incentive theory. Under adverse selection, the principal leaves some information rent to *bad* agents in order to elicit private information. The participation constraint of *bad* workers does not bind. We have $w^b > h^B$ with h^B the reservation wage of a *bad* worker and $(V^{B;b} - U^B) = (1+\beta)[u(w^b) - u(h^B)]$ the information rent. Incentive compatibility implies that contract g offers a higher starting wage than contract b does (eq. 8).

Alternatively, the contract b offered by the second menu provides each *bad* worker with no more than his reservation wage, which increases the incentive to shirk by reducing the expected value of contract b. The menu requires to offer a contract g with a lower starting wage in order to be incentive-compatible, and to offer more a than proportional increase in w_1^g in order to maintain the *good* worker's expected utility to its reservation level. According to eq. 9, the offer increases both with the degree of risk aversion and with the workers' ability gap that determines the gap between their expected reservation utility. The lower the ability of a *bad* worker, the lower his reservation wage, the lower the starting wage w_0^g that is incentive-compatible and thus the higher the second-period wage w_1^g that ensures *good* workers' participation.

[11] It implies that the ability gap between a *good* and a *bad* worker is higher than the gap between the output and the income from inactivity: $\frac{a^G}{a^B} \geq \frac{y}{h}$

Under adverse selection, the employer faces a trade off between giving up an information rent to *bad* workers (M_1) or reducing the starting wage offered by contract g (M_2) in order to prevent shirking. The optimality of the solution mainly depends on both the proportion of *good* workers in the economy and the strength of risk aversion. In an economy with a high proportion of *bad* workers, the offer M_2 should dominate the offer M_1 since the saving of the information rent increases the expected profit from a *bad* worker. Conversely, if the proportion of *good* workers is high enough, M_1 should dominate M_2 since a contract g with a flatter wage-tenure profile yields a higher expected profit from a *good* worker. Similarly, we expect M_1 to dominate M_2 for highly risk averse workers. Indeed, the employer would have to offer a greater salary increase to *good* workers in order to ensure their participation (which would reduce $\Pi^{G;g}$) and thus may prefer to leave an information rent to *bad* workers.

2.2.2 With firing costs

In what follows, we discuss the effects of firing costs on the optimal design of separating contracts.

Consider that the parameters of the economy are such that, for $F = 0$, the optimal menu of contracts is M_1, satisfying:

$$h^B < w^b_{F=0} < w^g_{0/F=0} < w^g_{1/F=0} < \chi$$

Assume an increase in firing costs. Dismissal of *bad* shirkers remains optimal as long as $F \leq w^g_{1/F=0} - y^B$. We thus define a threshold $\bar{F}$ such that for $0 \leq F \leq \bar{F}$ the optimal menu of separating contracts is not affected by an increase in F. This threshold is given by:

$$\bar{F} = w^g_{1/F=0} - y^B \tag{10}$$

For $F > \bar{F}$, the wage offer $w^g_{1/F=0}$ is no longer compatible with the dismissal constraint since the expected cost of retaining a *bad* shirker is lower than firing costs. Hence, the employer has to raise the offer w^g_1 so that dismissal of *bad* shirkers remains optimal. The dismissal constraint is now binding, which yields:

$$w^g_1 = F + y^B \equiv \omega^g_1(F) \qquad \textit{for} \;\; F \geq \bar{F} \tag{11}$$

For $F > \bar{F}$, an increase in firing costs results in a proportional increase in w^g_1. It allows the employer to reduce the starting wage offer (recall that the optimal contract g provides each *good* worker with no more than his expected reservation utility). From eq. 7 and 11, it satisfies:

$$w^g_0 = \left\{(1+\beta)(h^G)^{1-\sigma} - \beta\omega^g_1(F)^{1-\sigma}\right\}^{\frac{1}{1-\sigma}} \equiv \omega^g_0(F) \quad \textit{for} \;\; F \geq \bar{F} \tag{12}$$

with $\frac{\partial\omega^g_0(F)}{\partial F} < 0$, $|\frac{\partial\omega^g_0(F)}{\partial F}| < 1$ and $\frac{\partial^2\omega^g_0(F)}{\partial F^2} > 0$ (see appendix A.2).
Similarly, a reduction in w^g_0 diminishes the incentive to shirk of *bad* workers thus allowing the employer to lower the wage offer w^b. It implies that it exists a threshold of firing costs, denoted by $\tilde{F}$, for which the optimal contract b provides each *bad* worker with no more than their reservation wage. Replacing the expression of the CRRA utility function into IC_B (eq. 8) gives us:

$$w^b = \left\{\frac{1}{(1+\beta)}\omega^g_0(F)^{1-\sigma} + \frac{\beta}{(1+\beta)}(h^B)^{1-\sigma}\right\}^{\frac{1}{1-\sigma}} \equiv \omega^b(F) \qquad \textit{for} \; \bar{F} \leq F \leq \tilde{F} \tag{13}$$

with $\frac{\partial\omega^b(F)}{\partial F} < 0$, $|\frac{\partial\omega^b(F)}{\partial F}| < |\frac{\partial\omega^g_0(F)}{\partial F}|$ and $\frac{\partial^2\omega^b(F)}{\partial F^2} > 0$ (see appendix A.2).

We have $\omega^b(\tilde{F}) = h^B$, thus implying $\omega_0^g(\tilde{F}) = h^B$ and $\omega_1^g(\tilde{F}) = \chi$. The optimal pair of separating contracts for $F = \tilde{F}$ is M_2 while M_1 is no longer a candidate solution to the employer's problem for $F \geq \tilde{F}$. From eq. 11, it follows that the threshold $\tilde{F}$ satisfies:

$$\tilde{F} = \chi - y^B \tag{14}$$

Finally, for $F > \tilde{F}$, an additional increase in firing costs does not affect the optimal *bad* type's contract since reducing w^b would drive *bad* workers out of the labor market. We have:

$$w^b = h^B \qquad\qquad for \;\; F \geq \tilde{F} \tag{15}$$

It implies that for higher values of firing costs the incentive constraint no longer binds and a menu of contracts has to offer $w_0^g < w^b$ to be fully separating. We denote by M_3 the optimal menu of separating contracts for $F > \tilde{F}$:

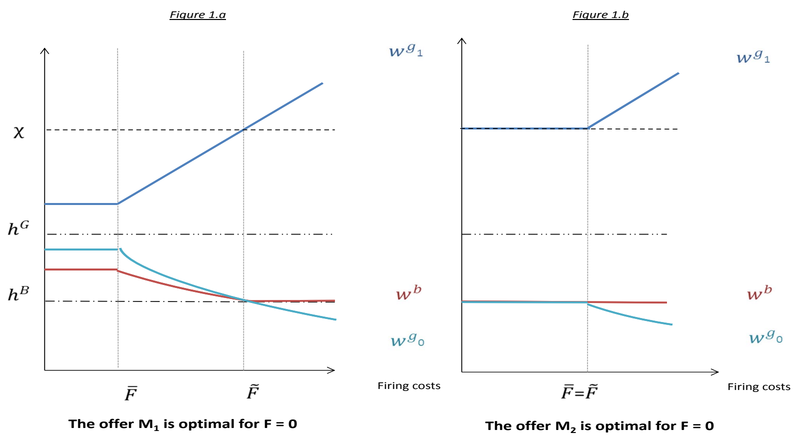
M_3 The starting wage offers are such that $w_0^g < w^b$ with $w^b = h^B$ (eq. 15). The contract g, satisfying eq. 11 and 12, provides each *good* worker with a strong salary increase ($w_1^g > \chi$).

Consider that the parameters of the economy are such that, for $F = 0$, the optimal menu of contracts is M_2, satisfying:

$$w^b_{F=0} = w^g_{0/F=0} = h^B \;\; and \;\; w^g_{1/F=0} = \chi$$

From eq. 10 and 14 we obtain $\bar{F} = \tilde{F}$ so that for $F \leq \tilde{F}$, the menu of separating contracts is not affected by and increase in F. As demonstrated previously, for $F > \tilde{F}$, the optimal menu of separating contract is M_3.

Figure 1: The effect of firing costs on the optimal design of contracts



Let us now investigate how an increase in firing costs from the level $\bar{F}$ affects the employer's expected profit, that satisfies:

$$\Pi_s = (1+\beta)\{\psi y^G + (1-\psi)y^B\} - \psi w_0^g - \psi\beta w_1^g - (1-\psi)(1+\beta)w^b \tag{16}$$

Using eq. 11, 12, 13 and 15, we express the total expected profit as a function of firing costs for $F \geq \bar{F}$:

$$\begin{aligned}\Pi_s(F/\bar{F} \leq F \leq \tilde{F}) = (1+\beta)\Big[\psi y^G + (1-\psi)y^B\Big] - \psi\Big[\omega_0^g(F) + \beta\omega_1^g(F)\Big] \\ - (1-\psi)(1+\beta)\omega^b(F)\end{aligned} \tag{17}$$

$$\Pi_s(F/F \geq \tilde{F}) = (1+\beta)\Big[\psi y^G + (1-\psi)y^B\Big] - \psi\Big[\omega_0^g(F) + \beta\omega_1^g(F)\Big] - (1-\psi)(1+\beta)h^B \quad (18)$$

The comparative static w.r.t firing costs is reported in appendix A.2. An increase in firing costs from $\bar{F}$ raises the offer w_1^g and implies a less than proportional decrease in the offer w_0^g, which reduces the expected profit from a *good* worker, while the information rent left to *bad* workers (if initially positive) vanishes which increases the expected profit from a *bad* worker from $\bar{F}$ to $\tilde{F}$. We find that the profit from a menu of contracts unambiguously decreases with F from $\bar{F}$ when workers are risk averse ($\sigma > 0$). We thus define a threshold F^o such that:

$$\Pi_s(F^o) = 0$$

Conditional on $\Pi_s(F/F=0) > 0$, the value of F^o is unique[12]. If $\Pi_s(\tilde{F}) \leq 0$, we have $\bar{F} < F^o \leq \tilde{F}$ while $\Pi_s(\tilde{F}) \geq 0$ implies $F^o \geq \tilde{F}$. We thus first determine the condition under which $\Pi_s(\tilde{F}) \geq 0$. Replacing the values of the wage offers ($w_1^g = \chi$ and $w_0^g = w^b = h^B$) into eq. 16 yields:

$$\Pi_s(\tilde{F}) = (1+\beta)\big[\psi(y^G - h^B) + (1-\psi)(y^B - h^B)\big] - \beta\psi(\chi - h^B) \quad (19)$$

Therefore, $\Pi_s(\tilde{F}) \geq 0$ if :

$$\chi \leq h^B + \frac{1+\beta}{\beta}\left\{(y^G - h^B) + \frac{1-\psi}{\psi}(y^B - h^B)\right\} \equiv \tilde{\chi} \quad (20)$$

Finally, using eq. 17 and 18, we show that:

(*i*) If $\chi \geq \tilde{\chi}$, F^o is such that $\bar{F} < F^o \leq \tilde{F}$ and satisfies:

$$(1+\beta)y^G + (1+\beta)\frac{1-\psi}{\psi}\Big[y^B - \omega^b(F^o)\Big] - \omega_0^g(F^o) - \beta\omega_1^g(F^o) = 0 \quad (21)$$

(*ii*) If $\chi \leq \tilde{\chi}$, F^o is such that $F^o \geq \tilde{F}$ and satisfies:

$$(1+\beta)y^G + (1+\beta)\frac{1-\psi}{\psi}(y^B - h^B) - \omega_0^g(F^o) - \beta\omega_1^g(F^o) = 0 \quad (22)$$

We find that the threshold above which a menu of contracts cannot be implemented as it would yield a negative expected profit decreases both with the strength of risk aversion and with the proportion of *good* workers in the economy. Risk aversion not only reduces the expected profit for a given level of F but also raises the expected loss of profits induced by an increase in firing costs, by reducing the decrease in the starting wage offers[13]. Next, we find that the threshold F^o is a decreasing and convex function with respect to the proportion of *good* workers. The decrease in F^o is strongly reduced as soon as F^o falls below the threshold $\tilde{F}$ (that does not depend on ψ). Indeed, although an increase in ψ has ambiguous effects on Π_s for a given level of firing costs, it raises the expected loss of profits from *good* workers induced by an increase in F and reduces the expected gains of profits from *bad* workers as long as $F \leq \tilde{F}$.
Finally, the effects of an increase in the ability gap ($\searrow a^B$), which implies both a decrease in h^B and y^B, are less clear-cut. Firstly, the decrease of the output produced by a *bad* worker allows the employer to offer a contract g from M_1 with a flatter tenure profile: the offer w_1^g that ensures the optimality of a *bad* shirker's dismissal is reduced, which increases the starting wage offer w_0^g and raises the expected profit from a *good* worker for a given level of firing costs. One should

[12] If a menu of contracts yields zero profit in the absence of firing costs, we have $\Pi_s^E(F/F \leq \bar{F}) = 0$ which implies that F^o is not unique.

[13] According to eq. 11, 12 and 13, the offer w_1^g does not depend on σ while w_0^g increases with σ for a given level of firing costs as well as w^b for $F \in [\bar{F}; \tilde{F}]$. The LHT of eq. 21 and 22 decreases with F^o and σ.

notice that the decrease in y^B and w_1^g contributes respectively to increase and to reduce the cost of retaining a *bad* shirker $(w_1^g - y^B)$, so that the effects on the threshold $\bar{F}$ are ambiguous. Then, the decrease of the reservation wage of *bad* workers allows the employer to reduce the offer w^b while incentive-compatibility requires to increase the information rent left to *bad* workers (since the offer w_0^g is higher). Since the output y^B diminishes, we expect the profit from a *bad* worker to be reduced. Consequently, the effects on the total expected profit and on the expected loss of profits induced by an increase in firing costs are ambiguous.

2.3 The pooling equilibrium

We now propose to analyze the pooling equilibrium and investigate the optimality of contracts. A pooling contract is defined as a sequence of wages $\{w_0^p; w_1^p\}$ offered to both types of workers. Let V_p^i and Π_p^i be respectively the expected gains of a job to a worker with ability a^i and the expected profits to a firm employing a worker with ability a^i. In a pooling equilibrium, these values satisfy:

$$\Pi_p^i = y^i - w_0^p + \beta(y^i - w_1^p) \tag{23}$$

$$V_p^i = u(w_0^p) + \beta u(w_1^p) \tag{24}$$

The employer's program is:

$$\max_{w_0^p; w_1^p} \Pi_p = \psi \Pi_p^G + (1-\psi)\Pi_p^B = \sum_{t=0}^{1} \beta^t \left\{ \psi(y^G - w_t^p) + (1-\psi)(y^B - w_t^p) \right\}$$

subject to the participation constraints

$$V_p^G \geq U^G$$
$$V_p^B \geq U^B$$

We solve the optimization problem in appendix B. The optimal pooling contract is a single wage that equals the reservation wage of either *good* or *bad* workers: $w^p = \{h^B; h^G\}$. This result is quite intuitive. The employer faces a trade-off between offering a higher wage, $w^p = h^G$, that ensures the participation of all workers, or offering a lower wage, $w^p = h^B$, that only ensures the participation of *bad* workers. The seminal work of Akerlof (1970) already pointed out that under asymmetric information, "*good* cars" may be driven out of the market by "lemons". The optimal pooling wage depends on the proportion of *good* workers in the economy: the higher the risk of meeting a *bad* worker, the higher the incentive to offer a wage that provides each *bad* worker with his reservation wage. The expected profits the firm gets with $w_p = \{h^B, h^G\}$ are given by:

$$\Pi_p(\psi / w_p = h^B) = (1-\psi)(1+\beta)(y^B - h^B) \tag{25}$$

$$\Pi_p(\psi / w_p = h^G) = \psi(1+\beta)(y^G - h^G) + (1-\psi)(1+\beta)(y^B - h^G) \tag{26}$$

Eq. 26 is strictly increasing in ψ while eq. 25 is strictly decreasing in ψ: the expected profit increases with the proportion of *good* workers when *good* workers participate to the labor market while it increases with the share of *bad* workers when *good* workers do not participate. We define a threshold $\hat{\psi}$ such that $\Pi_p(\hat{\psi}/w_p = h^B) = \Pi_p(\hat{\psi}/w_p = h^G)$. This threshold is unique and satisfies:

$$\hat{\psi} = \frac{h^G - h^B}{y^G - h^B} \tag{27}$$

Therefore, for $\psi < \hat{\psi}$, we have $\Pi_p(\psi/w_p = h^B) > \Pi_p(\psi/w_p = h^G)$: the equilibrium pooling wage is $w^p = h^B$ and *good* workers are driven out of the labor market. The threshold $\hat{\psi}$ increases with the ability gap between workers (it decreases with the reservation wage of *bad* workers h^B).

2.4 Pooling versus Separating?

We now propose to investigate under which conditions a menu of separating contracts that elicit workers' private information is preferred to a pooling contract.

Using eq. 25 and 26, the expected profit the employer gets in a pooling equilibrium can be rewritten as follows:

$$\Pi_p(\theta) = (1+\beta)\big\{\theta\psi y^G + (1-\psi)y^B - \theta h^G - (1-\theta)(1-\psi)h^B\big\} \tag{28}$$

with $\theta = 1$ if $\psi \geq \hat{\psi}$ and $\theta = 0$ if $\psi < \hat{\psi}$ (*good* workers are driven out of the labor market).

A menu of separating contracts is preferred if $\Pi_s \geq \Pi_p(\theta)$. From eq. 16 and 28, we find that:

- For $\psi < \hat{\psi}$, the employer offers a menu of contracts if:

$$\psi\big\{(1+\beta)y^G - w_0^g - \beta w_1^g\big\} \geq (1+\beta)(1-\psi)(w^b - h^B) \tag{29}$$

- For $\psi \geq \hat{\psi}$, the employer offers a menu of contracts if:

$$(1+\beta)h^G \geq \psi\big\{w_0^g + \beta w_1^g\big\} + (1+\beta)(1-\psi)w^b \tag{30}$$

The interpretation of these conditions is quite straightforward. For $\psi < \hat{\psi}$, the employer decides whether to propose a menu of separating contracts or to offer a pooling wage that only *bad* workers would accept. According to eq. 29, a menu of contracts is preferred if the expected profit from a *good* worker is sufficient to cover the expected information rent left to a *bad* worker (that could be either positive or null). Alternatively, for $\psi \geq \hat{\psi}$, *good* workers participate in a pooling equilibrium. Then, the employer simply decides which type of wage contract to offer by comparing their respective expected costs (see eq. 30).

To deepen the analysis, let us now assume that a menu of contracts is preferred[14] for $F \leq \bar{F}$ and analyze the conditions under which it remains optimal for higher values of firing costs. Since the expected profit in a pooling equilibrium does not depend on F, there is a unique value of firing costs above which a pooling wage is preferred to a menu of separating contracts. This threshold value, denoted by F_θ^p, is such that:

$$\Pi_s(F_\theta^p) = \Pi_p(\theta) \tag{31}$$

It is straightforward that if $\Pi_s(\tilde{F}) \geq \Pi_p(\theta)$, we have $\Pi_s(F/\bar{F} \leq F \leq \tilde{F}) \geq \Pi_p(\theta)$ thus implying $F_\theta^p \geq \tilde{F}$, while $\Pi_s(\tilde{F}) \leq \Pi_p(\theta)$ implies $F_\theta^p \leq \tilde{F}$. Replacing the values of the wage offers ($w_1^g = \chi$ and $w_0^g = w^b = h^B$) into eq. (16) and (28) gives us the conditions under which $\Pi_s^E(\tilde{F}) \geq \Pi_p^E(\theta)$:

- For $\psi < \hat{\psi}$, $\Pi_s(\tilde{F}) \geq \Pi_p(\theta = 0)$ if:

$$\chi \leq y^G - \frac{1}{\beta}(y^G - h^B) \equiv \bar{\chi}(\theta = 0) \tag{32}$$

- For $\psi \geq \hat{\psi}$, $\Pi_s(\tilde{F}) \geq \Pi_p(\theta = 1)$ if:

$$\chi \leq h^B + \frac{1}{\psi}\frac{(1+\beta)}{\beta}(h^G - h^B) \equiv \bar{\chi}(\theta = 1) \tag{33}$$

[14] We thus assume that $\Pi_s(F/F \leq \bar{F}) > \Pi_p(\theta)$ with $\Pi_s(F/F \leq \bar{F}) > 0$.

These conditions imply that there is a threshold level of w_1^g, denoted by $\bar{\chi}$, above which a pooling wage yields a higher expected profit than the menu M_2. One can observe that, from $\hat{\psi}$, this threshold level starts decreasing with the proportion of *good* workers in the economy: we have $\bar{\chi}(\theta = 0) = \bar{\chi}(\theta = 1)$ for $\psi = \hat{\psi}$. The incentive to offer a menu of contracts that elicits private information is reduced if there are few *bad* workers in the economy.

Finally, we show that:

(*i*) For $\psi < \hat{\psi}$, if $\chi \leq \bar{\chi}(\theta = 0)$, $F^p_{\theta=0}$ is such that $F^p_{\theta=0} \geq \tilde{F}$ and satisfies:

$$\omega_0^g(F^p_{\theta=0}) + \beta\omega_1^g(F^p_{\theta=0}) = (1+\beta)y^G \tag{34}$$

(*ii*) For $\psi < \hat{\psi}$, if $\chi \geq \bar{\chi}(\theta = 0)$, $F^p_{\theta=0}$ is such that $F^p_{\theta=0} \leq \tilde{F}$ and satisfies:

$$\omega_0^g(F^p_{\theta=0}) + \beta\omega_1^g(F^p_{\theta=0}) + (1+\beta)\frac{(1-\psi)}{\psi}\omega^b(F^p_{\theta=0}) = (1+\beta)\left[y^G + \frac{(1-\psi)}{\psi}h^B\right] \tag{35}$$

(*iii*) For $\psi \geq \hat{\psi}$, if $\chi \leq \bar{\chi}(\theta = 1)$, $F^p_{\theta=1}$ is such that $F^p_{\theta=1} \geq \tilde{F}$ and satisfies:

$$\omega_0^g(F^p_{\theta=1}) + \beta\omega_1^g(F^p_{\theta=1}) = (1+\beta)\left[\frac{1}{\psi}h^G - \frac{(1-\psi)}{\psi}h^B\right] \tag{36}$$

(*iiii*) For $\psi \geq \hat{\psi}$, if $\chi \geq \bar{\chi}(\theta = 1)$, $F^p_{\theta=1}$ is such that $F^p_{\theta=1} \leq \tilde{F}$ and satisfies:

$$\omega_0^g(F^p_{\theta=1}) + \beta\omega_1^g(F^p_{\theta=1}) + (1+\beta)\frac{(1-\psi)}{\psi}\omega^b(F^p_{\theta=1}) = (1+\beta)\frac{1}{\psi}h^G \tag{37}$$

The threshold of firing costs above which a pooling wage is preferred to a menu of separating contracts decreases with the degree of risk aversion since it reduces the expected profit from a menu of contracts (the LHT of eq. 34 to 37 are increasing with both F^p_θ and σ.). The effects of the proportion of *good* workers and the ability gap are less clear-cut since it affects both the separating and the pooling equilibrium. However, since F^o decreases with ψ while $\Pi^p(\theta = 1)$ increases with ψ, we expected that the threshold $F^p_{\theta=1}$ diminishes with the proportion of *good* worker[15].

3 Numerical exercises

We now rely on numerical exercises to deepen the analysis. We propose the parametrization that is reported in Table 1 while sensitivity tests on σ, ψ and a^B will be provided. The output produced by a *good* worker is normalized to one: $y = 1$ and $a^G = 1$. Since the employer does not have any information about the worker's type prior to observing the output flow, we consider that the ability gap between *good* and *bad* workers is not of major importance[16]. We arbitrarily choose a benchmark value of $a^B = 0.8$, which implies an ability gap of 20%, and we consider a range from 0% to 50% for the sensitivity analysis[17]. As usual, we consider a relative risk aversion parameter $\sigma \in]1; 3]$ and choose an intermediate value $\sigma = 2$ for the benchmark computation. Finally, we arbitrarily set $\psi = 0.75$ (as explained thereafter).

[15]The numerical exercises suggest indeed that F^p decreases with ψ from $\hat{\psi}$.

[16]The ability gap between workers with different levels of qualifications and training might be important. However, as pointed out by the seminal work of Spence M. (1973), education would provide a signal about the worker's ability and reduce information asymmetry. In this paper, we thus consider heterogenous workers with a low ability gap so that information asymmetry remains.

[17]Carillo-Tudela C. & Kaas L. (2011) fixed an ability gap of 50% in their numerical exercise.

Table 1: Benchmark computation

Parameters		Values	Targets
Discount factor	β	0.99	Yearly interest rate of 4%
			Unit of time = quarter
Relative risk aversion	σ	2	
$\hookrightarrow$ *Sensitivity analysis*	σ	$\in]1;3]$	
Good worker's ability	a^G	1	Normalization
Bad worker's ability	a^B	0.8	Gap of 20%
$\hookrightarrow$ *Sensitivity analysis*	a^B	$\in [0.5;1]$	Gap of 0% up to 50%
Output production	y	1	Normalization
$\Rightarrow$	y^G	1	
$\Rightarrow$	y^B	0.8	
Home production	h	0.9	To ensure that $y^B < h^G$
$\Rightarrow$	h^G	0.9	$\Rightarrow$ Dismissal of *bad* shirkers
$\Rightarrow$	h^B	0.72	is optimal for $F = 0$
Proportion of *good* workers	ψ	0.75	Arbitrary value
$\hookrightarrow$ *Sensitivity analysis*	ψ	$\in [0;1]$	
Firing costs	F	$\in [0;1]$	in % of the output produced
			by a *good* worker y^G

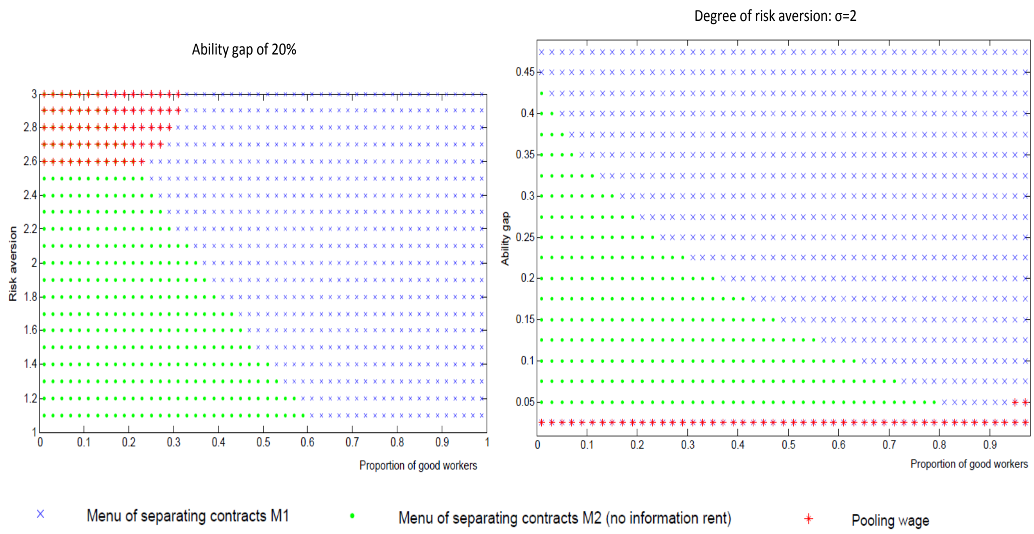
3.1 The optimal equilibrium in the absence of firing costs

We first propose to investigate the optimal contracts in the absence of firing costs according to the proportion of *good* workers in the economy, to the degree of workers' risk aversion and to the ability gap between *good* and *bad* workers.

Let us start by considering an ability gap of 20% while $\psi \in]0;1[$ and $\sigma \in]1;3]$. We find that in the absence of firing costs, a menu of separating contracts is optimal whatever the degree of risk aversion as long as the proportion of *good* workers in the economy is higher than 31% (see figure 2). For $\psi < 0.31$, if workers are highly risk averse, the employer prefers to offer a pooling wage that drives *good* workers out of the labor force (since $\hat{\psi} = 0.643$). Indeed, in a separating equilibrium with strong risk aversion, the contract g has a steep wage-tenure profile. The expected profit from *good* workers is either negative or lower than the sum of the information rents left to *bad* workers since there are not enough *good* workers in the economy (see eq. 29). Then, the exercises with $\sigma = 2$ while $\psi \in]0;1[$ and $a^B \in [0.5;1[$ show that the pooling wage is optimal as long as the ability gap does not exceed 5%, whatever the proportion of *good* workers in the economy (see figure 2): it is straightforward that there is no incentive to offer a menu of contracts that elicits the worker's private information in an economy with quite similar workers. However, if $\psi < 31\%$, *good* workers are driven out of the labor force (recall that $\hat{\psi}$ increases with the ability gap).

Numerical exercises suggest that the proportion of *good* workers and the ability gap are the main determinants of the trade-off between the two menus of separating contracts. Recall that M_1 and M_2 differ by both the wage-tenure profile of contract g (resp. flat or steep) and the information rent provided by contract b (resp. positive or null). As expected, there is a threshold value of ψ above which the menu M_1 dominates M_2. This threshold decreases with workers' risk aversion since it raises the cost of the contract g offered by M_2 more than the cost of the one offered by M_1. However, for an ability gap of 20%, we find that if the proportion of *good* workers is high enough, $\psi > 62\%$, the optimal menu is M_1 whatever the degree of risk aversion while if $\psi < 13\%$, the optimal menu is M_2 (see figure 2). Besides, the threshold value of ψ above which

Figure 2: The optimal contracts for $F = 0$



the employer prefers to offer M_1 also decreases with the ability gap and the menu M_1 is optimal whatever the value of ψ if the ability gap is high enough). A larger ability gap implies that the contract g strongly differs from M_1 to M_2, such that the gain from offering a flatter profile more than compensates for the loss from leaving an information rent to *bad* workers.

Figure 3 illustrates that when M_1 is offered, w_1^g decreases with both σ and ψ while w_0^g and w^b increases. The contract g has to offer a flatter wage-tenure profile in order to reduce the cost to the employer. Then, the contract b requires to leave a higher information rent in order to discourage *bad* workers from shirking. Conversely, the proportion of *good* workers in the economy does not affect the design of M_2 while risk aversion requires to provide a higher salary increase to *good* workers in order to compensate for the low starting wage. Finally, the total expected profit decreases with the degree of risk aversion but is U-shaped with ψ. In fact, as long as M_2 is offered, $\Pi^{G,g} < \Pi^{B,b}$ and the total expected profit diminishes first with the proportion of *good* workers. Then, while M_1 is offered, the expected profit from a *good* and a *bad* worker respectively raises and decreases with ψ. The minimum value of the total expected profit is reached for ψ such that $\Pi^{G,g} = \Pi^{B,b}$. Surprisingly enough, we observe that for $a^B = 0.8$, the proportion of *good* workers has to be at least of 75% to ensure a higher expected profit than in the absence of any *good* workers whatever the strength of risk aversion. We thus propose to set $\psi = 0.75$ in the benchmark computation.

Finally, figure 4 illustrates the effects of an increase in the ability gap for $\psi = 0.75$ and $\sigma = 2$ (detailed results for different values of ψ are provided in appendix C.2). A larger ability gap implies a decrease in the reservation wage of *bad* workers which raises their incentive to shirk. Therefore, even though the wage offer w^b can be reduced, an incentive compatible menu of contracts has to provide either (i) a contract g with a lower starting wage offer and a stepper wage tenure profile (if M_2 is offered), or (ii) a contract b that leaves a greater information rent to *bad* workers which allows the employer to increase w_0^g and reduce w_1^g (if M_1 is offered). We thus observe that as the ability gap increases, the optimal tenure profile of contract g first gets steeper (as long as M_2 is offered) and then flatter (when M_1 is offered, from an ability gap of 7.5%), so that $\Pi^{G,g}$ decreases first and then increases. One should notice that, whatever the proportion of *bad* workers, the total expected profit is strongly reduced as adverse selection phenomenon gets stronger (see appendix C.2). In fact, the expected profit from a *bad* worker decreases with the ability gap since the output produced by a *bad* worker diminishes more than the wage offered by contract b.

Figure 3: The separating equilibrium for $F = 0$ according to ψ and σ - *Ability gap of 20%*

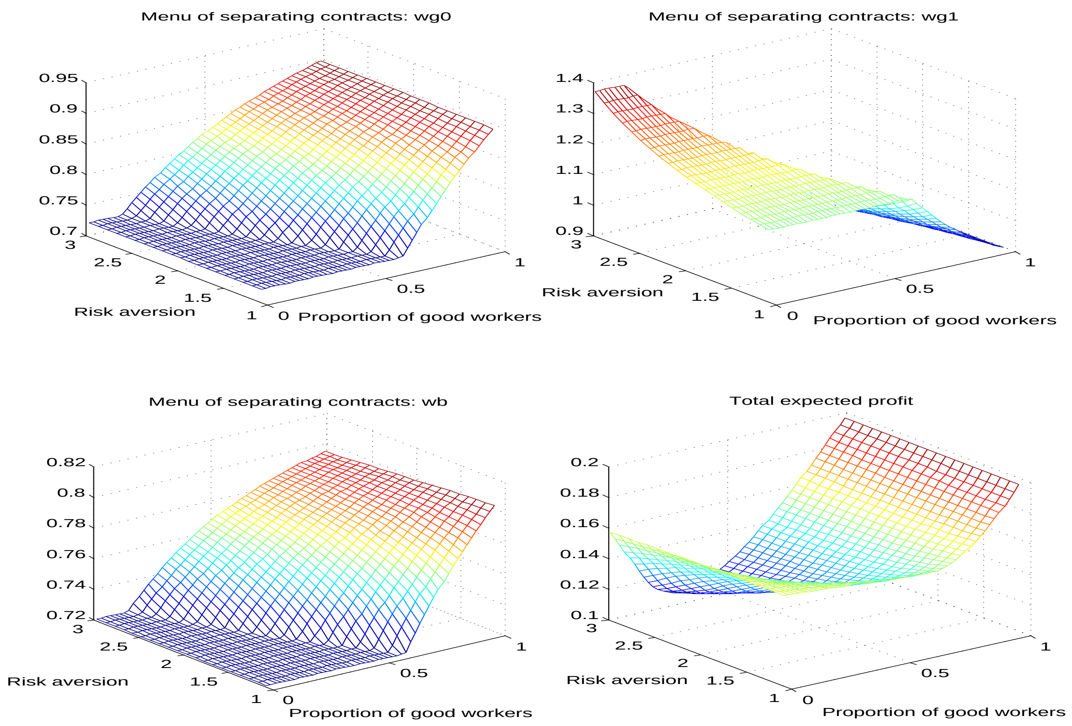
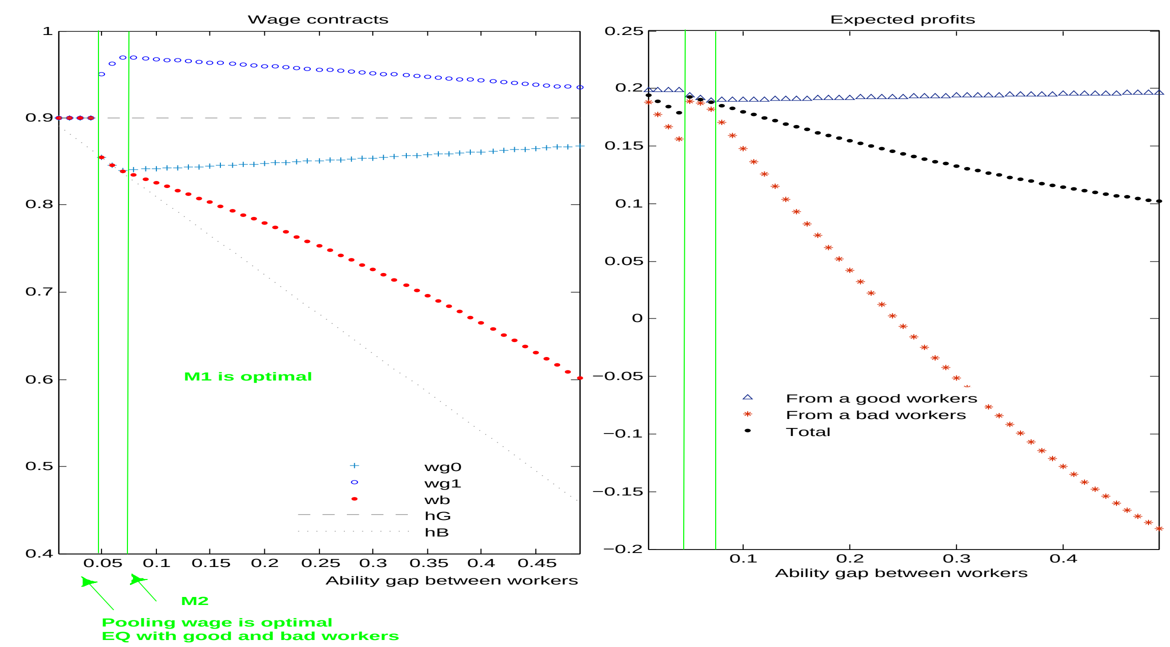


Figure 4: Results for $F = 0$ according to the ability gap - *Risk aversion* $\sigma = 2$*, proportion of good workers of* 75%

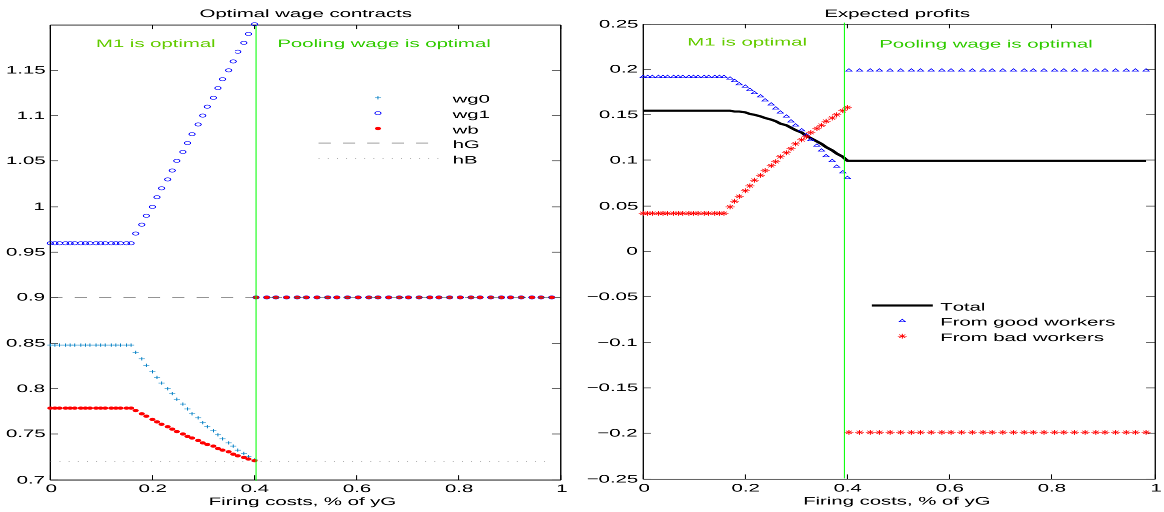


3.2 The effects on firing costs on the optimal contract

We now turn to analyze the effects of firing costs on the optimal wage contracts. We start by using the benchmark computation and provide a sensitivity analysis on ψ and a^B.

We first find that a separating equilibrium only exists if the level of firing costs is lower than 59% of the output produced by a *good* worker ($F^o = 0.59$). The benchmark computation implies that M_1 is optimal for $F = 0$. We have $\bar{F} = 0.1597$ so that separating contracts are affected by an increase in firing costs from low levels of employment protection. As explained previously, an increase in firing costs reduces the information rent which is left to a *bad* worker while the wage-tenure profile of contract g gets steeper. Since the probability to meet with a *good* worker is high, the total expected profit is strongly reduced from the threshold $\bar{F}$. Consequently, we find that a pooling wage is preferred as soon as the level of firing costs exceeds 40% of the output produced by a *good* worker: we have $F^p_{\theta=1} < \tilde{F}$ with $\tilde{F} = 0.404$. Since the proportion of *good* workers is high enough, the optimal pooling wage is $w^p = h^G$ and *good* workers are not driven out of the labor market.

Figure 5: Results according to the level of firing costs



3.2.1 Variation in the proportion of *good* workers (ψ)

Detailed results are provided in appendix C.1. Firstly, in an economy with few *good* workers, $\psi < 0.36$, M_2 is optimal for $F = 0$. Separating contracts are not affected by an increase in firing costs up to the threshold $\tilde{F}$, that remains equal to 40.1%, and the separating equilibrium does not depend on the proportion of *good* workers in the economy. Conversely, from $\psi > 0.36$, the menu of contracts that is optimal in the absence of firing costs is M_1. As explained above, the optimal wage tenure profile of contract g gets flatter as ψ increases. Therefore, for a given level of firing costs, dismissal may no longer be optimal since w_1^g is reduced. From $\psi = 0.36$, the higher the proportion of *good* workers in the economy, the lower the threshold $\bar{F}$ above which the menu of contracts is affected by an increase in F.
Then, an increase in the proportion of *good* workers raises the loss of profits from a steep wage-tenure profile of contract g. Therefore, the employer faces a trade off between reducing the cost of contract g by offering a flatter wage tenure profile and offering w_1^g that is high enough to ensure the optimality of *bad* shirkers' dismissal. We find that the threshold level above which the pooling wage is preferred does not depend on ψ as long as $\psi < \hat{\psi}$ since *good* workers are

driven out of the labor force in the pooling equilibrium (see eq. 34): we get $F^p_{\theta=0} = 0.524 > \tilde{F}$. Consequently, for levels of firing costs between 40% and 52.4% of the output, the employer offers a menu of contracts such that $w_0^g < w^b$ in order to elicit private information. Finally, from $\psi > \hat{\psi}$, the higher the proportion of *good* workers in the economy, the lower the threshold value of firing costs above which the pooling wage is preferred since the expected profit in the pooling equilibrium, $\Pi^p(\theta = 1)$, increases with ψ. We get $F^p_{\theta=1} < \tilde{F}$ from $\psi \geq 0.74$.

3.2.2 Variation in the ability gap (a^B)

Detailed results are reported in appendix C.2. Firstly, we find that the higher the ability gap, the higher the threshold level of firing costs above which the optimal design of separating contracts is affected by an increase in F. Recall that the menu of contracts offered in the absence of firing costs remains optimal as long as dismissal is less costly than retaining a *bad* shirker ($F \leq w_1^g - y^B$). We find that the reduction in the output produced by a *bad* worker is such that the cost of retaining a *bad* shirker increases with the ability gap. However, as explained previously, the offer w_1^g of menu M_1 diminishes with the ability gap (for $F < \bar{F}$), thus reducing the expected cost of retaining a *bad* shirker. Therefore, the increase in $\bar{F}$ is slightly reduced when M_1 is offered, from an ability gap of 7.5%.
Then, as adverse selection phenomenon gets stronger, the incentive to offer a menu of contracts that elicits the worker's private information raises for high levels of firing costs: the higher the ability gap, the higher the threshold level of firing costs above which the pooling wage is offered (it reaches more than 70% of the output produced by a *good* worker for an ability gap of 50%). Although the expected profit from a menu of contracts is reduced with the ability gap (due to the decrease in $\Pi^{B;b}$), the level of firing costs above which the separating equilibrium is affected by F increases and the expected profit from a pooling wage is reduced with the ability gap. Consequently, both F^o and F^p_θ increases. We observe that from a value of 34%, the ability gap is so high that, even though there are many *good* workers in the economy, the employer offers a wage that drive *good* workers out of the labor force in a pooling equilibrium.

4 Wage cut

So far, we assumed that dismissal is the only form of punishment to a *bad* shirker. An alternative would be to allow the employer to cut the wage of these workers. As pointed out by Carillo-Tudela C. & Kaas L. (2011), it is straightforward that cutting the wage so that low-ability workers get no more than their reservation utility dominates the firing of shirkers. For instance, assume that once detected, a *bad* shirker receives in period 1 no more than his outside option h^B. It is an equally threat than dismissal since it provides the same expected utility to the worker, $u(w_0^g) + \beta u(h^B)$, while the employer continues to extract rents out of this worker. Consequently, wage cut dominates dismissal for $F > \bar{F}$, as a separating contract with the threat of dismissal is affected by an increase in firing costs and yields a lower expected profit. The separating equilibria in the absence of firing costs do not differ whatever the threat.

However, one can argue that employers might be unwilling to reduce the wage. In fact, a well known result of the personnel and behavioral economics literature is that reducing the wage diminishes workers motivations thereby reducing the productivity (see for instance Fehr E. & Gächter S. (1998) and Fehr E. & Falk A. (1999) as well as Akerlof G. (1982) for the gift exchange approach to labor market). Even though we do not consider workers' effort, we assume downward nominal wage rigidities and propose to investigate an alternative option. Assume that, instead of cutting the wage of a *bad* shirker to h^B, the punishment is a wage freeze: a *bad* shirker would thus receive w_0^g in both periods. The incentive constraint is now:

$$u(w_0^b) + \beta u(w_1^b) - (1+\beta)u(w_0^g) \geq 0 \qquad (IC_B^w) \qquad (38)$$

We find that[18]:

(i) The optimal menu of contracts offers two identical starting wages:

$$w_0^g = w^b \tag{39}$$

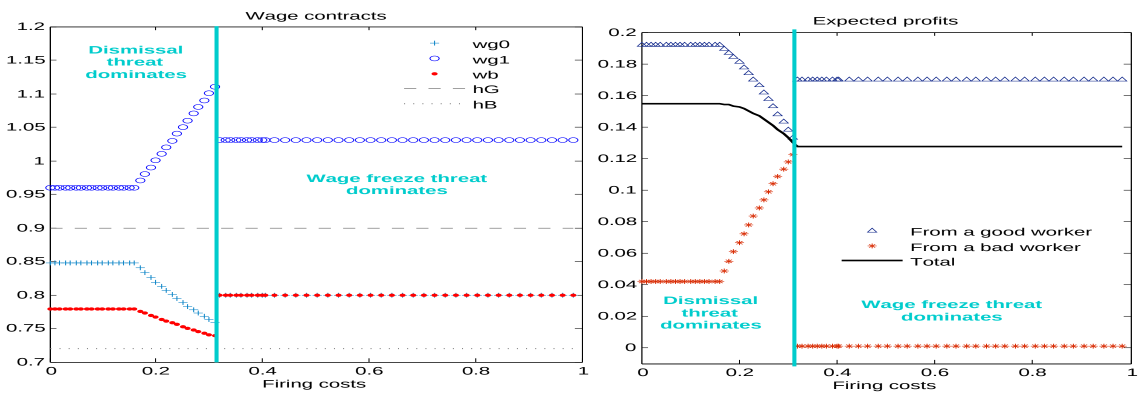
(ii) The optimal menu of contracts provides every *good* worker with no more than their reservation expected utility:

$$u(w_0^g) + \beta u(w_1^g) = (1+\beta)u(h^G) \tag{40}$$

(iii) There are two candidate solutions depending on whether or not the participation constraint of *bad* workers binds: either $w^b > h^B$ and the menu provides each *bad* worker with an information rent, or $w^b = h^B$ and the menu M_2 is offered with a contract g that has a steep wage-tenure profile.

As previously, one can expect that the trade-off between those two menus depends on the strength of risk aversion, the proportion of *good* workers in the economy, and on the ability gap between *good* and *bad* workers. We find that there exists a threshold of firing costs, F^w, above which the threat of a wage freeze dominates the one of dismissal. If wage freeze is a possible form of punishment, the separating equilibrium dominates the pooling equilibrium whatever the level of firing costs. Figure 6 illustrates the results with the benchmark computation. The employer leaves an information rent to *bad* workers which is higher than with dismissal as a threat. The *wage freeze* dominates *dismissal* from a level of firing costs of 32% ($\bar{F} < F^w < \tilde{F}$).

Figure 6: Results according to the level of firing costs (2)



[18]Details of the resolution are available upon request.

5 Conclusion

This paper supports the idea that employers are induced to offer self selection wage contracts to workers who differ by their abilities as labor markets operate under adverse selection. Our main contribution is to investigate the role of firing costs in self-selection mechanisms. We develop a two-period principal-agent model in which two types of risk-averse workers have private information about their abilities. In order to infer workers' abilities prior hiring, the employer offers a menu of contracts that specifies a sequence of wages with dismissal being the punishment to a worker who overstated his ability.

Dismissal works as a self selection mechanism as long as it remains a credible threat. The strictness of Employment Protection Legislation thus affects the optimal design of wage contracts. We first show that the employer offers a single wage that might leave each *bad* worker with an information rent while this information rent vanishes as the level of firing costs increases. At the same time, a pair of sully separating contracts provides each *good* worker with a rising wage-tenure profile that gets steeper with the level of firing costs. The promotion of *good* workers has to be high enough so that dismissal of *bad shirkers* remains a credible threat and the starting wage offer has to be low enough in order to discourage shirking. Hence, for high levels of dismissal costs, the wage received by a *bad* worker exceeds the starting wage of a *good* worker. The expected profit from a menu of contracts decreases with firing costs so that we find that there is a threshold above which a pooling wage that might drive *good* workers out of the labor market is preferred.

However, numerical exercises suggest that the level of firing costs above which a pooling wage is preferred to a menu of contracts is quite low whatever the parameters of the economy (indeed, it does not exceed the value of the output produced by a *good* worker). According to our findings, the EPL that characterizes European countries is such that separating contracts with dismissal as the only form of punishment is not optimal. However, we do not argue that EPL should be reduced in order to resolve information asymmetries since our results point out that firstly, a marginal reform would have no impact, and secondly that firms can use wage freeze as an alternative self selection mechanism for higher values of firing costs. Besides, numerical exercises show that separating contracts with wage freeze provide a higher wage to *bad* workers while the wage tenure profile of *good* workers is flatter. It suggests that in economies with low EPL, wage dispersion should be higher as well as wage increases compared to economies characterized by a strict EPL, which is consistent with the empirical evidence on firms' salary practices observed in USA vs. Europe.

Finally, our paper focuses on the effects of dismissal costs on optimal wage contracts and does not investigate the impact on firms' hiring practices. Kugler A. & Saint-Paul G. (2004) argued that as firing costs increase, firms are induced to hire employed workers under adverse selection to reduce the risk of hiring a *lemon*. One can expect that these practices are used when self selection mechanisms cannot be implemented or yield lower profits. Indeed, both practices (offering separating contracts or hiring an employed worker) reduce information asymmetries but can be costly. Therefore, an interesting extension of our work could be to investigate the conditions under which separating contracts are preferred and the impact on wage dispersion and job-to-job transitions.

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A The separating equilibrium

A.1 The optimal design of separating contracts

The employer's problem is the following:

$$\max_{w_0^j;w_1^j} \Pi_s^E = \psi \Pi^{G,g} + (1-\psi)\Pi^{B,b} = \sum_{t=0}^{1} \beta^t \Big\{ \psi(y^G - w_t^g) + (1-\psi)(y^B - w_t^b) \Big\}$$

subject to the participation constraints

$$\begin{aligned} & V^{G,g} \geq U^G && (PC_G) \\ \Leftrightarrow \quad & u(w_0^g) + \beta u(w_1^g) - (1+\beta)u(h^G) \geq 0 \end{aligned}$$

$$\begin{aligned} & V^{B,b} \geq U^B && (PC_B) \\ \Leftrightarrow \quad & u(w_0^b) + \beta u(w_1^b) - (1+\beta)u(h^B) \geq 0 \end{aligned}$$

to the adverse selection incentive constraints

$$\begin{aligned} & V^{G,g} \geq V^{G,b} && (IC_G) \\ \Leftrightarrow \quad & u(w_0^g) + \beta u(w_1^g) - u(w_0^b) - \beta u(w_1^b) \geq 0 \end{aligned}$$

$$\begin{aligned} & V^{B,b} \geq V^{B,g} && (IC_B) \\ \Leftrightarrow \quad & u(w_0^b) + \beta u(w_1^b) - u(w_0^g) - \beta u(h^B) \geq 0 \end{aligned}$$

and to the dismissal constraint

$$\begin{aligned} & \Pi^{B;g}_{\phi_g^B=1} \geq \Pi^{B;g}_{\phi_g^B=0} && (DC) \\ \Leftrightarrow \quad & [y^B - w_0^g - \beta F] - [y^B - w_0^g + \beta(y^B - w_1^g)] \geq 0 \end{aligned}$$

The lagrangian is:

$$\begin{aligned} L = {} & \psi\big[(1+\beta)y^G - w_0^g - \beta w_1^g\big] + (1-\psi)\big[(1+\beta)y^B - w_0^b - \beta w_1^b\big] \\ & + \lambda_{pg}\big[u(w_0^g) + \beta u(w_1^g) - (1+\beta)u(h^G)\big] \\ & + \lambda_{pb}\big[u(w_0^b) + \beta u(w_1^b) - (1+\beta)u(h^B)\big] \\ & + \lambda_{ig}\big[u(w_0^g) + \beta u(w_1^g) - u(w_0^b) - \beta u(w_1^b)\big] \\ & + \lambda_{ib}\big[u(w_0^b) + \beta u(w_1^b) - u(w_0^g) - \beta u(h^B)\big] \\ & + \lambda_d\big[w_1^g - F - y^B\big] \end{aligned}$$

The first order necessary optimality conditions are:

$$\begin{aligned}
(C_1)\quad & \frac{\partial L}{\partial w_0^b} = -(1-\psi) + (\lambda_{pb} - \lambda_{ig} + \lambda_{ib})u'(w_0^b) = 0 \\
(C_2)\quad & \frac{\partial L}{\partial w_1^b} = -\beta(1-\psi) + \beta(\lambda_{pb} - \lambda_{ig} + \lambda_{ib})u'(w_1^b) = 0 \\
(C_3)\quad & \frac{\partial L}{\partial w_0^g} = -\psi + (\lambda_{pg} + \lambda_{ig} - \lambda_{ib})u'(w_0^g) = 0 \\
(C_4)\quad & \frac{\partial L}{\partial w_1^g} = -\beta\psi + \beta(\lambda_{pg} + \lambda_{ig})u'(w_1^g) + \lambda_d = 0
\end{aligned}$$

$$\begin{aligned}
(C_5)\quad & \lambda_{pg}\big[u(w_0^g) + \beta u(w_1^g) - (1+\beta)u(h^G)\big] = 0 \\
(C_6)\quad & \lambda_{pb}\big[u(w_0^b) + \beta u(w_1^b) - (1+\beta)u(h^B)\big] = 0 \\
(C_7)\quad & \lambda_{ig}\big[u(w_0^g) + \beta u(w_1^g) - u(w_0^b) - \beta u(w_1^b)\big] = 0 \\
(C_8)\quad & \lambda_{ib}\big[u(w_0^b) + \beta u(w_1^b) - u(w_0^g) - \beta u(h^B)\big] = 0 \\
(C_9)\quad & \lambda_d\big[w_1^g - F - y^B\big] = 0
\end{aligned}$$

Proposition 1. *The optimal contract b offers a monotone wage.*

Proof: From the conditions (C_1) and (C_2), we get:

$$u'(w_0^b) = u'(w_1^b) \quad \Longrightarrow \quad w_0^b = w_1^b \equiv w^b \tag{41}$$

Proposition 2. *The optimal contract g provides each good worker with his expected reservation utility:*

$$u(w_0^g) + \beta u(w_1^g) = (1+\beta)u(h^G) \tag{42}$$

Proof: It is straightforward that the *good* agent's incentive constraint is non-binding. The expected reservation utility of *good* workers is higher than the one of *bad* workers so that they have no incentive to misreport their type. Besides, a binding constraint would imply that *good* workers are indifferent between both contracts: $(1+\beta)u(w^b) = u(w_0^g) + \beta u(w_1^g)$. From PC_G, we would get $u(w^b) \geq u(h^G)$. Since with risk aversion, a monotone wage is less costly to the firm than a non-monotone wage that provides the same expected utility to the worker, the optimal contract would be a pooling wage: $w^b = w^g = h^G$. Therefore, we necessarily have $(1+\beta)u(w^b) < u(w_0^g) + \beta u(w_1^g)$ and thus set $\lambda_{ig} = 0$ for the rest of the analysis. The condition (C_3) yields:

$$(\lambda_{pg} - \lambda_{ib}) = \frac{\psi}{u'(w_0^g)} > 0 \tag{43}$$

Since the Lagrange multipliers has positive or null value, $\lambda_{pg} \neq 0$, the participation constraint of *good* workers necessarily bind at the optimum.

Proposition 3. *The optimal contract g offers a rising wage-tenure profile with:*

$$w_0^g < h^G < w_1^g$$

Proposition 4. *Let us define a constant χ as follows:*

$$\chi = \left\{ \frac{1+\beta}{\beta}(h^G)^{1-\sigma} - \frac{1}{\beta}(h^B)^{1-\sigma} \right\}^{\frac{1}{1-\sigma}} \tag{44}$$

There is a threshold $\tilde{F} = \chi - y^B$ such that:

- *For $F < \tilde{F}$, there are two candidate solutions to the adverse selection problem:*

  M_1 *The menu of contracts offers $h^B < w^b < w_0^g < h^G < w_1^g < \chi$ with $w_1^g \geq F + y^B$.*

  The constraints PC_B and DC do not bind while IC_B does.

  M_2 *The menu of contracts offers $w_0^g = w^b = h^B$ and $w_1^g = \chi > F + y^B$.*

  Both PC_B and IC_B bind while DC does not bind.

- *For $F = \tilde{F}$, the employer offers the menu M_2: $w_0^g = w^b = h^B$ and $w_1^g = \chi = \tilde{F} + y^B$. The dismissal constraint is binding.*

- *For $F > \tilde{F}$, the employer offers a third menu M_3 such that contract b provides $w^b = h^B$ while contract g offers $w_0^g < w^b$ and $w_1^g = F + y^B > \chi$.*
  The constraints PC_B and DC bind while IC_B does not.

Proof to propositions 3 and 4: We consider two cases depending on whether or not PC_B binds.

Let us start by assuming that the participation constraint of bad workers binds. It yields $u(w^b) = u(h^B)$. We replace the value of the wage offer w^b by h^B into (IC_B) and get:

$$(1+\beta)u(h^B) \geq u(w_0^g) + \beta u(h^B) \qquad \Rightarrow \qquad u(w_0^g) \leq u(h^B)$$

Recall that contract g provides each *good* worker with his expected reservation utility. Since $w_0^g \leq h^B$, it is straightforward that the optimal contract g offers a rising wage-tenure profile to *good* workers with $w_1^g > h^G$. Risk-aversion implies that a reduction in w_0^g requires a more than proportional increase in w_1^g to ensure *good* workers' participation. Consequently, offering the highest level of w_0^g that prevents *bad* workers from shirking, $w_0^g = h^B$, is less costly to the employer. Using the expression of the CRRA utility function, we show that for $w_0^g = h^B$, the level of w_1^g that satisfies PC_G is:

$$w_1^g = \left\{ \frac{1+\beta}{\beta}(h^G)^{1-\sigma} - \frac{1}{\beta}(h^B)^{1-\sigma} \right\}^{\frac{1}{1-\sigma}} \equiv \chi \tag{45}$$

However, the dismissal constraint imposes $w_1^g \geq F + y^B$: the second-period wage provided by contract g has to be high enough in order to ensure the optimality of a *bad* shirker's dismissal. We define a threshold of firing costs $\tilde{F}$ such that for $F \leq \tilde{F}$, the offer $\{w^b = h^B; w_0^g = h^B; w_1^g = \chi\}$ is fully separating. This threshold is given by:

$$\tilde{F} = \chi - y^B \tag{46}$$

On the contrary, for $F > \tilde{F}$, the contract g has to offer a higher second-period wage. Recall that the higher w_1^g, the lower w_0^g and the lower the expected profit $\Pi^{G;g}$. The employer thus offers:

$$w_1^g = F + y^B \equiv \omega_1^g(F) \tag{47}$$

and the dismissal constraint is binding. The starting wage that satisfies PC_G is thus:

$$w_0^g = \left\{ (1+\beta)(h^G)^{1-\sigma} - (F + y^B)^{1-\sigma} \right\}^{\frac{1}{1-\sigma}} \equiv \omega_0^g(F) \tag{48}$$

For $F > \tilde{F}$, $\omega_1^g(F) > \chi$ and $\omega_0^g(F) < h^B$ so that the incentive constraint of *bad* workers does not bind. It means that to be fully separating, a menu of contracts has to provide each *good* worker with a lower starting wage than each *bad* worker.

Let us now consider that the participation constraint of bad workers is non-binding: $(1+\beta)u(w^b) > (1+\beta)u(h^B)$. The employer gives up an information rent to *bad* workers, $w^b > h^B$. According to (C_6), $\lambda_{pb} = 0$ so that condition (C_1) yields:

$$\lambda_{ib} = \frac{1-\psi}{u'(w^b)} > 0$$

The incentive constraint of *bad* workers necessarily binds and we obtain:

$$u(w_0^g) = u(w^b) + \beta[u(w^b) - u(h^B)] \qquad \Rightarrow \qquad u(w_0^g) > u(w^b)$$

Besides, the conditions (C_3) and (C_4) yield:

$$(\lambda_{pg} - \lambda_{ib}) = \frac{\psi}{u'(w_0^g)} > 0 \tag{49}$$

$$(\beta\psi - \lambda_d) = \beta\lambda_{pg}u'(w_1^g) > 0 \tag{50}$$

which implies:

$$\frac{u'(w_0^g)}{u'(w_1^g)} = \frac{\lambda_{pg}}{(\lambda_{pg} - \lambda_{ib})} \cdot \frac{\beta\psi}{(\beta\psi - \lambda_d)} \tag{51}$$

We have $\frac{\beta\psi}{(\beta\psi - \lambda_d)} \geq 1$ and a positive value of λ_{ib} implies $\frac{\lambda_{pg}}{(\lambda_{pg} - \lambda_{ib})} > 1$. We thus find:

$$\frac{u'(w_0^g)}{u'(w_1^g)} > 1$$

The optimal contract g offers a rising wage-tenure profile with $w_0^g < h^G < w_1^g$. Since $w_0^g > h^B$, we have $w_1^g < \chi$. The dismissal constraint imposes $w_1^g > F + y^B$. Therefore, the menu of contracts is a candidate solution to the adverse selection problem for $F < \tilde{F}$ but would not be fully separating for $F \geq \tilde{F}$.

A.2 Comparative static w.r.t firing costs

Assuming that $\Pi_s^E(F/F < \bar{F}) > 0$, we analyze how firing costs affect the separating equilibrium for $F \geq \bar{F}$. Recall that if M_2 dominates M_1 for $F = 0$, we have $\bar{F} = \tilde{F}$. The expected profit and the optimal wage offers of a menu of contracts satisfy:

$$\Pi_s^E = \psi\Pi^{G,g} + (1-\psi)\Pi^{B;b}$$

with

$$\Pi^{G;g} = (1+\beta)y^G - w_0^g - \beta w_1^g$$
$$\Pi^{B;b} = (1+\beta)(y^B - w^b)$$

and with:

$$w_1^g = \omega_1^g(F) = F + y^B \qquad\qquad for\ F \geq \bar{F}$$

$$w_0^g = \omega_0^g(F) = \left\{(1+\beta)(h^G)^{1-\sigma} - \beta\omega_1^g(F)^{1-\sigma}\right\}^{\frac{1}{1-\sigma}} \qquad\qquad for\ F \geq \bar{F}$$

$$w^b = \begin{cases} \omega^b(F) = \left\{\frac{1}{(1+\beta)}\omega_0^g(F)^{1-\sigma} + \frac{\beta}{(1+\beta)}(h^B)^{1-\sigma}\right\}^{\frac{1}{1-\sigma}} & for\ \bar{F} \leq F \leq \tilde{F} \\ h^B & for\ F \geq \tilde{F} \end{cases}$$

Proposition 5. *If workers are risk averse ($\sigma > 0$), an increase in firing costs from $\bar{F}$ implies a proportional increase in the wage offer w_1^g, which results in a less than proportional decrease in w_0^g. The function $\omega_1^g(F)$ is a linear function, strictly increasing in F while $\omega_0^g(F)$ is a strictly decreasing convex function of the level of firing costs.*

$$\frac{\partial \omega_1^g(F)}{\partial F} = 1 \;\; ; \qquad \frac{\partial \omega_0^g(F)}{\partial F} < 0 \;\; ; \;\; |\frac{\partial \omega_0^g(F)}{\partial F}| < 1 \;\; ; \qquad \frac{\partial^2 \omega_0^g(F)}{\partial F^2} > 0$$

Proof: It is straightforward that $\frac{\partial \omega_1^g(F)}{\partial F} = 1$ and $\frac{\partial^2 \omega_1^g(F)}{\partial F^2} = 0$. Differentiating the function $\omega_0^g(F)$ with respect to firing costs yields:

$$\frac{\partial \omega_0^g(F)}{\partial F} = \frac{1}{1-\sigma}\left\{(-\beta)(1-\sigma)\frac{\partial \omega_1^g(F)}{\partial F}\omega_1^g(F)^{-\sigma}\right\}\omega_0^g(F)^{\sigma}$$

which simplifies to:

$$\frac{\partial \omega_0^g(F)}{\partial F} = -\beta\left[\frac{\omega_0^g(F)}{\omega_1^g(F)}\right]^{\sigma} \qquad < 0 \tag{52}$$

According to proposition 3, we have $\frac{w_0^g}{w_1^g} < 1$ so that $|\frac{\partial \omega_0^g(F)}{\partial F}| < 1$.

The second derivative satisfies:

$$\frac{\partial^2 \omega_0^g(F)}{\partial F^2} = -\beta\sigma\left\{\frac{\frac{\partial \omega_0^g(F)}{\partial F}\omega_1^g(F) - \omega_0^g(F)}{\omega_1^g(F)^2}\right\}\left[\frac{\omega_0^g(F)}{\omega_1^g(F)}\right]^{\sigma-1} \qquad > 0$$

Indeed, since $\frac{\partial \omega_0^g(F)}{\partial F} < 0$, we get $\frac{\partial \omega_0^g(F)}{\partial F}\omega_1^g(F) < \omega_0^g(F)$.

Proposition 6. *If workers are risk averse ($\sigma > 0$), an increase in firing costs from $\bar{F}$ to $\tilde{F}$ implies a less than proportional reduction in w^b, that is lower than the one of w_0^g, while from $\tilde{F}$, the level of firing costs no longer affects the offer w^b. The function $\omega^b(F)$ is convex and decreasing in the level of firing costs on $[\bar{F}; \tilde{F}]$.*

$$\frac{\partial \omega^b(F)}{\partial F} < 0 \;\; ; \qquad |\frac{\partial \omega^b(F)}{\partial F}| < |\frac{\partial \omega_0^g(F)}{\partial F}| < 1 \;\; ; \;\; \frac{\partial^2 \omega^b(F)}{\partial F^2} > 0$$

Proof: It is straightforward that for $F \geq \tilde{F}$, $\frac{\partial w^b}{\partial F} = 0$ while differentiating the function $\omega^b(F)$ with respect to F yields:

$$\frac{\partial \omega^b(F)}{\partial F} = \frac{1}{1+\beta}\frac{\partial \omega_0^g(F)}{\partial F}\left[\frac{\omega^b(F)}{\omega_0^g(F)}\right]^{\sigma} \qquad < 0$$

which simplifies to:

$$\frac{\partial \omega^b(F)}{\partial F} = -\frac{\beta}{1+\beta}\left[\frac{\omega^b(F)}{\omega_1^g(F)}\right]^{\sigma} \qquad < 0 \tag{53}$$

According to proposition 4, we have $\left[\frac{\omega^b(F)}{\omega_0^g(F)}\right] \leq 1$ so that $|\frac{\partial\omega^b(F)}{\partial F}| < |\frac{\partial\omega_0^g(F)}{\partial F}|$.

The second derivative satisfies:

$$\frac{\partial^2\omega^b(F)}{\partial F^2} = -\frac{\beta\sigma}{1+\beta}\left[\frac{\omega^b(F)}{\omega_1^g(F)}\right]^{\sigma-1}\left\{\frac{\frac{\partial\omega^b(F)}{\partial F}\omega_1^g(F) - \omega^b(F)}{\omega_1^g(F)^2}\right\} > 0 \qquad (54)$$

Indeed, since $\frac{\partial\omega^b(F)}{\partial F} < 0$, we get $\frac{\partial\omega^b(F)}{\partial F}\omega_1^g(F) < \omega^b(F)$.

Proposition 7. *If workers are risk averse ($\sigma > 0$), an increase in firing costs reduces the expected profit from a good worker from $\bar{F}$ while it increases the expected profit from a bad worker for $\bar{F} \leq F \leq \tilde{F}$. The total expected profit is a concave and decreasing function with respect to the level of firing costs on the support $[\bar{F};\infty[$.*

Proof: Differentiating the expected profits with respect to F yields:

$$\frac{\partial\Pi_s(F)}{\partial F} = -\psi\frac{\partial\Pi^{G;g}(F)}{\partial F} - (1-\psi)\frac{\partial\Pi^{B;b}(F)}{\partial F}$$

with

$$\frac{\partial\Pi^{G;g}(F)}{\partial F} = -\frac{\partial\omega_0^g(F)}{\partial F} - \beta\frac{\partial\omega_1^g(F)}{\partial F} = -\beta\left\{1 - \left[\frac{\omega_0^g(F)}{\omega_1^g(F)}\right]^\sigma\right\} < 0 \qquad for\ F \geq \bar{F}$$

and with

$$\frac{\partial\Pi^{B;b}(F)}{\partial F} = \begin{cases} -(1+\beta)\frac{\partial\omega^b(F)}{\partial F} = \beta\left[\frac{\omega^b(F)}{\omega_1^g(F)}\right]^\sigma > 0 & for\ \bar{F} \leq F \leq \tilde{F} \\ 0 & for\ F \geq \tilde{F} \end{cases}$$

Since workers are risk averse ($\sigma > 0$), the expected profit from a *good* worker is strictly decreasing in the level of firing costs. On the contrary, the expected profit from a *bad* worker increases with F from $\bar{F}$ to $\tilde{F}$. Although the effect of firing costs on the total expected profit is *a priori* ambiguous between the two thresholds while the total expected profit unambiguously decreases from the threshold $\tilde{F}$, we find that the total expected profit is a monotonic concave function, strictly decreasing in the level of firing costs on $[\bar{F};\infty[$.

The first and second derivatives of the total expected profit satisfy:

$$\frac{\partial\Pi_s(F/\bar{F} \leq F \leq \tilde{F})}{\partial F} = -\beta\psi\left\{1 - \left[\frac{\omega_0^g(F)}{\omega_1^g(F)}\right]^\sigma\right\} + \beta(1-\psi)\left[\frac{\omega^b(F)}{\omega_1^g(F)}\right]^\sigma < 0 \qquad (55)$$

$$\frac{\partial\Pi_s(F/F \geq \tilde{F})}{\partial F} = -\beta\psi\left\{1 - \left[\frac{\omega_0^g(F)}{\omega_1^g(F)}\right]^\sigma\right\} < 0 \qquad (56)$$

$$\frac{\partial^2\Pi_s(F/\bar{F} \leq F \leq \tilde{F})}{\partial F^2} = -\psi\frac{\partial^2\omega_0^g(F)}{\partial F^2} - (1+\beta)(1-\psi)\frac{\partial^2\omega^b(F)}{\partial F^2} < 0 \qquad (57)$$

$$\frac{\partial^2\Pi_s(F/F \geq \tilde{F})}{\partial F^2} = -\psi\frac{\partial^2\omega_0^g(F)}{\partial F^2} < 0 \qquad (58)$$

First, using propositions 5 and 6, we find that the two functions, $\Pi_s(F/\bar{F} \leq F \leq \tilde{F})$ and $\Pi_s(F/F \geq \tilde{F})$ are both monotonic and concave (eq. 57 and 58). Consequently, having $\frac{\partial\Pi_s(F/\bar{F}\leq F\leq\tilde{F})}{\partial F} \geq 0$ would imply that the function $\Pi_s(F)$ has a maximum for $\tilde{F}$, $\frac{\partial\Pi_s(\tilde{F})}{\partial F} = 0$, which is not possible since, as explained above, $\frac{\partial\Pi_s(\tilde{F}/F\geq\tilde{F})}{\partial F} < 0$.

B The pooling equilibrium

The firm's problem is:

$$\max_{w_0^p;w_1^p} \Pi_p = \psi\Pi_p^G + (1-\psi)\Pi_p^B = \sum_{t=0}^{1} \beta^t \Big\{ \psi(y^G - w_t^p) + (1-\psi)(y^B - w_t^p) \Big\}$$

subject to the participation constraints

$$V_p^G \geq U^G$$
$$V_p^B \geq U^B$$

The lagrangian is:

$$\begin{aligned} L = {} & \psi\big[(1+\beta)y^G - w_0^p - \beta w_1^p\big] + (1-\psi)\big[(1+\beta)y^B - w_0^p - \beta w_1^p\big] \\ & + \lambda_{pg}\big[u(w_0^p) + \beta u(w_1^p) - (1+\beta)u(h^G)\big] \\ & + \lambda_{pb}\big[u(w_0^p) + \beta u(w_1^p) - (1+\beta)u(h^B)\big] \end{aligned}$$

The first order necessary optimality conditions are:

$$\begin{aligned} &(C_1) \quad \frac{\partial L}{\partial w_0^p} = -1 + (\lambda_{pg} + \lambda_{pb})u'(w_0^p) = 0 \\ &(C_2) \quad \frac{\partial L}{\partial w_1^p} = -\beta + \beta(\lambda_{pg} + \lambda_{pb})u'(w_1^p) = 0 \\ &(C_3) \quad \lambda_{pg}\big[u(w_0^p) + \beta u(w_1^p) - (1+\beta)u(h^G)\big] = 0 \\ &(C_4) \quad \lambda_{pb}\big[u(w_0^p) + \beta u(w_1^p) - (1+\beta)u(h^B)\big] = 0 \end{aligned}$$

From the first order conditions (C_1) and (C_2), we have: $u'(w_0^p) = u'(w_1^p)$. Given our assumptions on the utility function $u(.)$, the optimal wage is constant over periods: $w_0^p = w_1^p \equiv w^p$.

C Sensitivity tests

C.1 The proportion of *good* workers (ψ)

We use the benchmark computation and simulate a variation in $\psi \in]0;1[$. Figure 7 illustrates that the threshold $\bar{F}$ decreases with the proportion of *good* workers from $\psi = 0.36$ (since the menu M_1 is the one that is optimal for $F = 0$) and that from $\psi = \hat{\psi}$ with $\hat{\psi} = 0.643$, the threshold level of firing costs above which the pooling wage is preferred decreases with ψ since *good* workers would not be driven out of the labor force in a pooling equilibrium. As an illustration, the detailed results for $\psi < 0.36$, $\psi = 0.5$ and $\psi = 0.9$ are represented respectively by figures 8, 9 and 10.

Figure 7: Economy with a proportion of *good* workers $\in]0;1[$

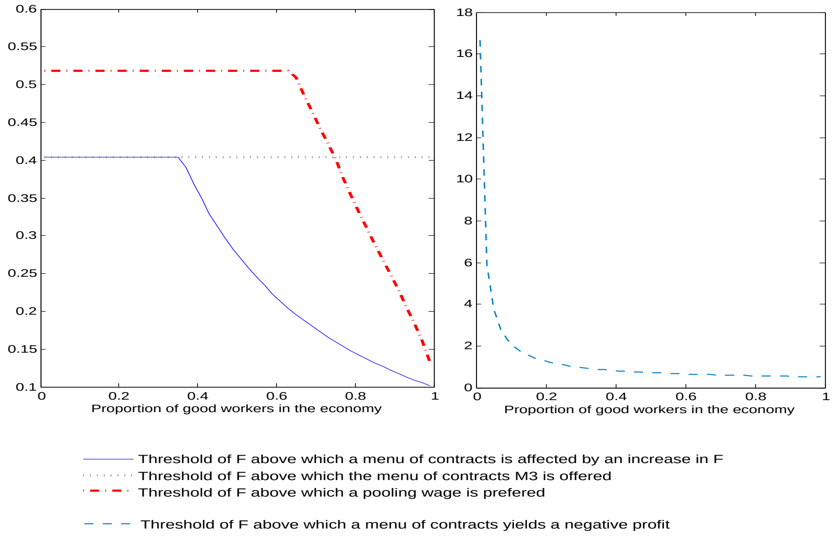


Figure 8: The effects of firing costs - $\psi < 0.36$

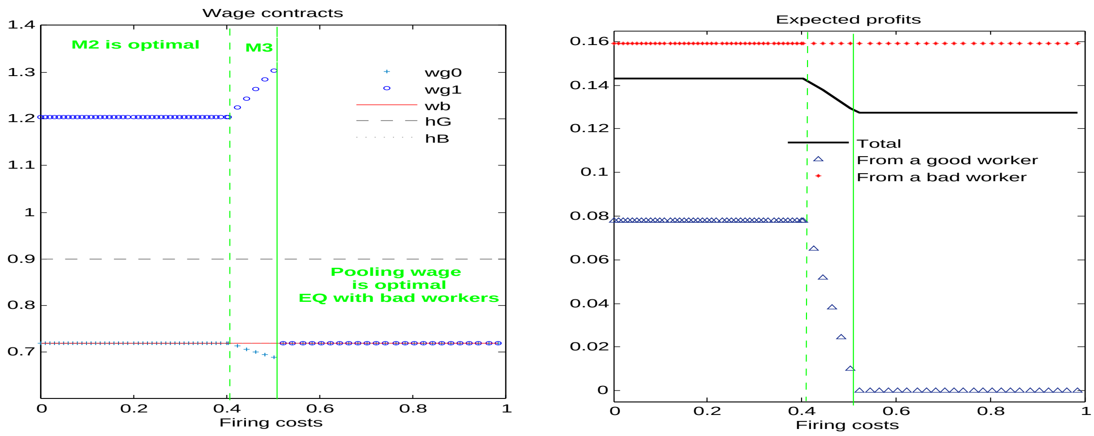


Figure 9: The effects of firing costs - $\psi = 0.5$

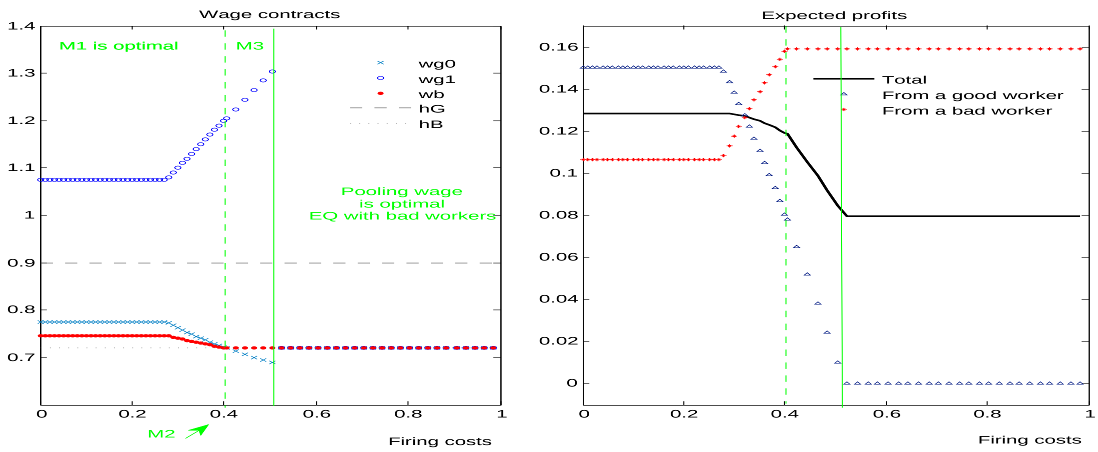
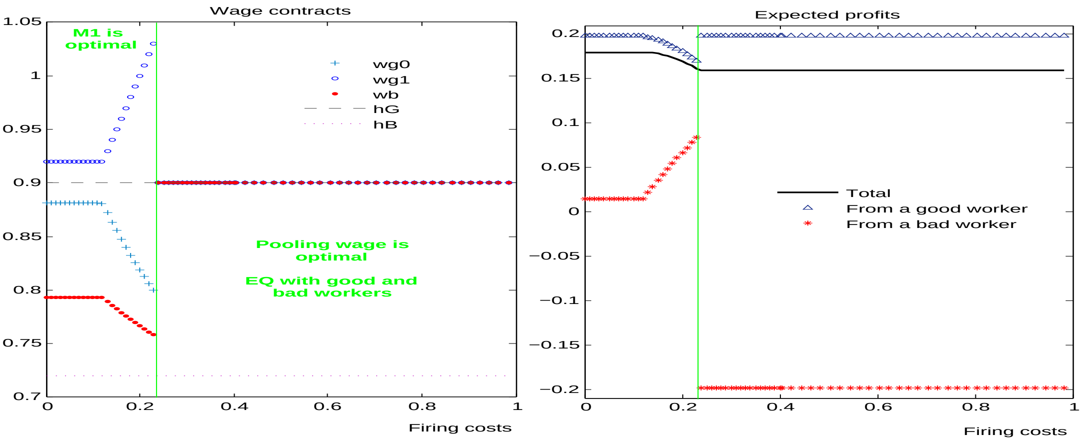


Figure 10: The effects of firing costs - $\psi = 0.9$



C.2 The ability gap (a^B)

We keep the benchmark computation and simulate a variation in $a^B \in [0.5; 1[$ which corresponds to an ability gap $\in]0; 50\%]$. Figures 11, 12 and 13 illustrate the results in the absence of firing costs for an economy with a proportion of *good* workers of respectively 25%, 50% and 90%.

Figure 11: Results for $F = 0$ according to the ability gap ($\psi = 25\%$)

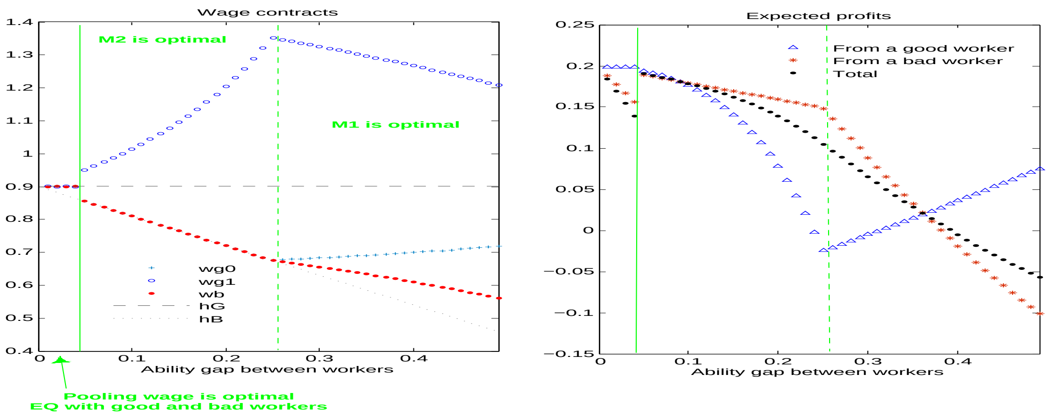


Figure 12: Results for $F = 0$ according to the ability gap ($\psi = 50\%$)

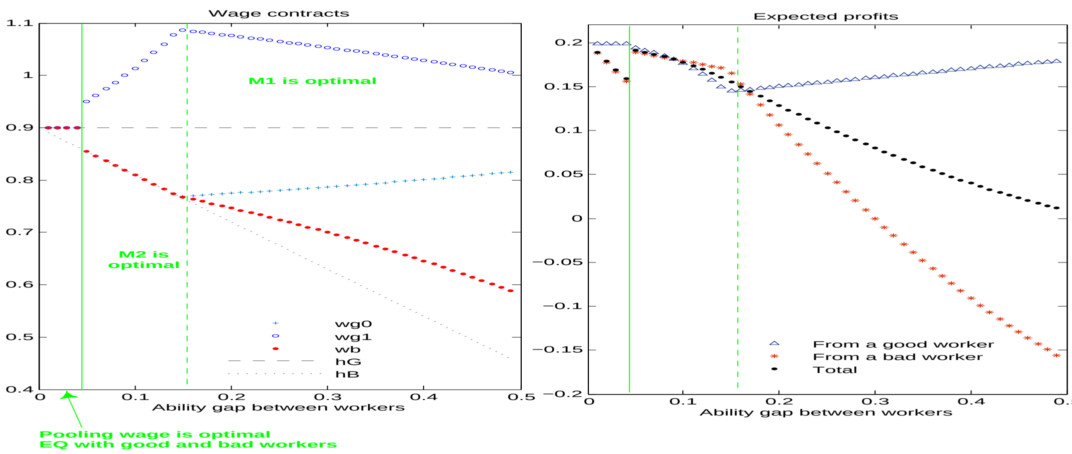


Figure 13: Results for $F = 0$ according to the ability gap ($\psi = 90\%$)

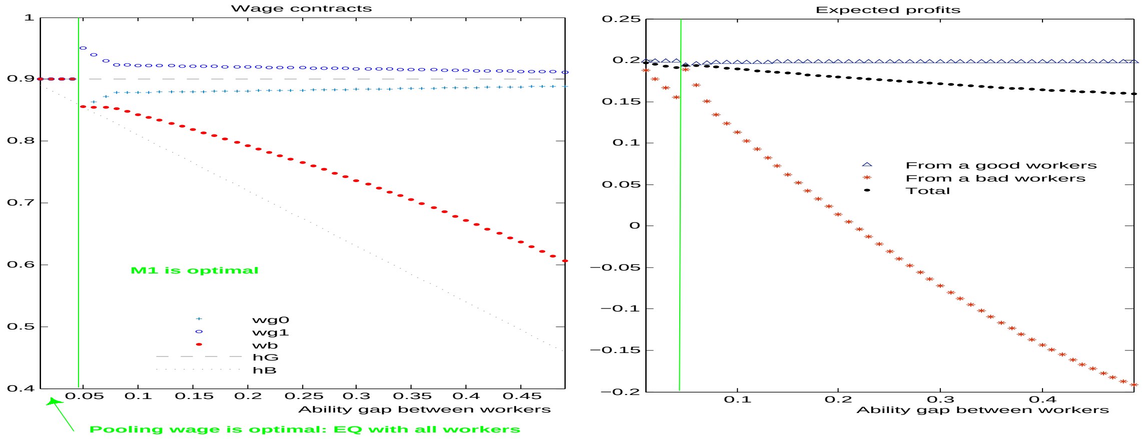


Figure 14 illustrates that the thresholds $\bar{F}$, $\tilde{F}$, F^p_θ and F^o increase with the ability gap. From a gap of 34%, the pooling equilibrium is such that *good* workers do not participate in the labor market. Figures 15, 16 and 17 display the numerical results of an increase in firing costs for an ability gap of respectively 15%, 30% and 45%.

Figure 14: Economy with an ability gap $\in]0; 50\%]$ ($\psi = 75\%$)

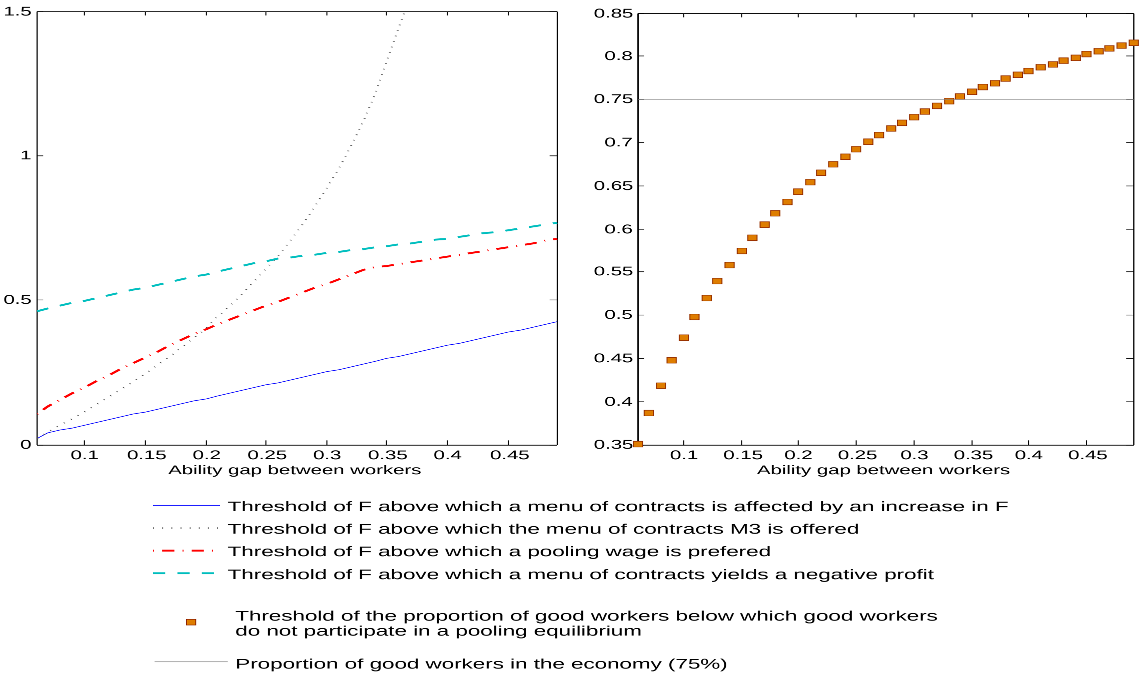


Figure 15: The effects of firing costs - Ability gap of 15%, ($\psi = 75\%$)

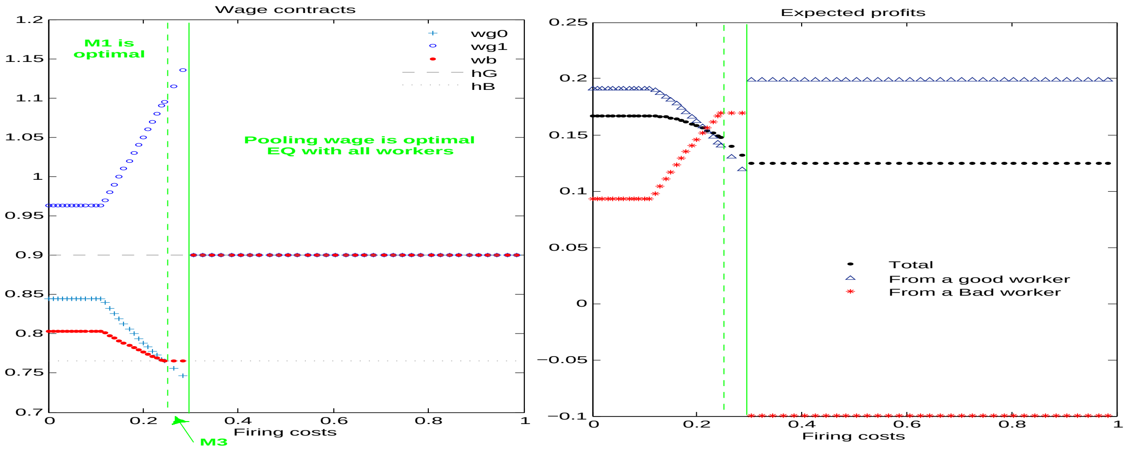


Figure 16: The effects of firing costs - Ability gap of 30%, ($\psi = 75\%$)

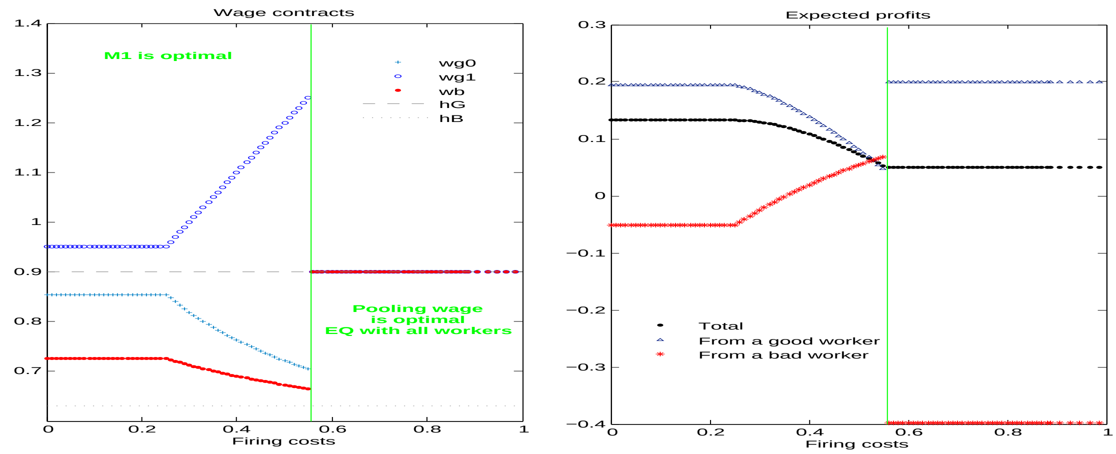


Figure 17: The effects of firing costs - Ability gap of 45%, ($\psi = 75\%$)