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Can Information Explain the Trade-Off?

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Abstract

In Italy, following WWII, specific hiring procedures were developed that prevented firms from screening workers. More in particular, these institutions characterized the Italian labor market with respect to the US labor market, and were gradually removed during the 1990s. A simple matching model in which the usual Nash bargaining criterion is replaced by a game of incomplete information, shows that such hiring procedures endogenously generate wage compression within groups of observationally equivalent workers, as well as higher unemployment rates. Both the estimated behavior of within-group wage inequality in Italy, computed from the micro-data of the SHIW panel of the Bank of Italy, and the behavior of the unemployment rate in the late 1990s, are consistent with the predictions of the model.

Keywords: job-search, labor market institutions, within-group wage inequality, bargaining with incomplete information, screening.

JEL Classification: C78; J31; J64

1 Introduction

To explain the different performance of OECD countries in terms of unemployment and wage inequality, the theoretical and empirical literature has investigated the role of different institutions such as minimum wages, unemployment benefits, employment protection and centralization in wage bargaining. Many of these studies have documented the existence of a trade-off between unemployment and wage inequality, and for the most part they have focused on total inequality in the aggregate wage distribution.[1] Little research instead has investigated the sources of within group wage inequality, i.e., wage dispersion within groups of observationally equivalent workers. As Acemoglu (2002, p.14) points out "we know relatively little about the determinants of residual inequality,...[or] about cross-country differences in the behavior of wage inequality... [and] much more research in this topic is needed".

This paper contributes to fill the gap on the theoretical side by presenting a novel determinant of unemployment and within-group wage inequality which implies a trade-off between the two. The focus is on the broad set of institutions which prevent firms from screening workers. Lazear (1995) shows that firms can extract information about the non-observable determinants of workers' productivity through the use of screening tests. I argue that the amount of information that can be extracted is affected by labor market institutions. I thus define institutions preventing screening (hereafter IPS) as all the rules and regulations that may, directly or indirectly, prevent firms from obtaining information which is useful to predict workers' productivity.

As it is carefully documented in the next section, IPS had a fundamental importance in the functioning of the Italian labor market. Following WWII, the cornerstone of the Italian labor market regulation, Act 264 of 1949, prevented firms from choosing directly the workers they wanted to hire. Instead, workers could be hired only through public placement agencies. In the case of manual workers, firms could only make a numerical request to these agencies, specifying the number of workers they needed. The public agencies would have then selected the workers to be hired, on the basis of their economic need to find a job. Besides hindering screening procedures prior to forming a match, the Italian legislator, following post-war European standards, restricted access to temporary contracts and limited the duration of probationary periods. As a consequence, firms in the Italian labor market were also hindered in screening workers on the job. Briefly, firms could only draw up permanent contracts, having little information on the characteristics of the workers. IPS can be thus considered as a distinctive feature of the Italian labor market, and to some extent of the European labor market, as opposed to the US labor market. Nevertheless, as documented in the next section, the evolution of the Italian juridical system suggests that the influence of IPS has been strongly declining since the beginning of the 1990s.

In order to assess the effects of IPS, the standard matching model presented by Pissarides (2000) is extended in the following directions. First, workers are no longer identical: heterogeneity across workers reflects permanent differences in individual productivity. Second, as is common in adverse selection models of the labor market, individual productivity is known to the worker but not to the firm at the time the worker is hired. Third, contracts are bargained once and for all, and they cannot be

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[1]See Blau and Kahn (1999) for a review and Bertola, Blau and Kahn (2001).

conditional on future performance. Finally, it is assumed that a worker must take a screening test upon matching. The outcome of the screening test is for the firm a noisy signal over the productivity type. Labor market institutions affecting the information content of the screening procedures are modeled as a parameter defined over a continuous support which represents the precision of this signal. IPS are associated with a relatively low degree of precision. Changes in the parameter representing labor market institutions will allow all intermediate scenarios of incomplete information to be represented, ranging from the case in which the signal is completely uninformative to the case in which the signal reveals the worker's type perfectly.

The model requires solving a bargaining game of incomplete information. This is necessary since the commonly used Nash bargaining criterion is no longer applicable with one-sided imperfect information on the payoffs. The standard way for modeling bargaining in this case is to assume that either the worker or the firm makes a take-it or leave-it offer with given probabilities. This approach has been exploited in the context of macroeconomic models of the labor market also by Kennan (2006) and Tawara (2005), but for the opposite case in which the firm has private information over the productivity of the worker. In the modeling of this bargaining procedure, I add on their work by considering signal extraction. One feature of this game which makes it particularly attractive is that under perfect information the solution is the commonly used Nash bargaining criterion (Cahuc and Zylberberg 2004).

The model builds on the literature of asymmetric information in matching models with heterogeneous agents. Three papers that are worth mentioning in this field of study are Strand (2000), Montgomery (1999) and Pries and Rogerson (2005). Strand (2000) shows that a lack of information on workers' characteristics may lead firms to employ too few workers. His work is based on the assumption that in a market with no frictions firms can reward workers for their productivity after having paid a fixed screening cost. This paper departs from his study in two directions: frictions are introduced to analyze the behavior of unemployment at equilibrium, and imperfect screening to study the effects of IPS.

Montgomery (1999) builds a dynamic matching model with heterogeneous agents and adverse selection. While he assumes an exogenous wage rate, wage compression arises endogenously in this framework and reacts both to the composition of the unemployment pool and to the nature of labor market institutions.

Pries and Rogerson (2005) build a model to account for the fact that worker turnover in Europe is much less than in the US. While they assume workers to be homogeneous before matching, and information about match-specific productivity to be unobservable upon bargaining both for the worker and for the firm, in this paper workers are allowed to be ex-ante heterogeneous and to have private information about their type. Although Pries and Rogerson (2005) recognize the importance that screening procedures might have on the aggregate labor market equilibrium, they only investigate the role of standard labor market institutions, and do not analyze how the equilibrium changes with the precision of the screening procedures. This is the task I take up in this paper.

This work identifies two sources of within-group wage inequality. The first is random bargaining power and stems from the assumptions about the bargaining game: workers with the same observable and non-observable characteristics might be paid

differently as they could have different bargaining powers upon matching. The second source is the precision of the signal, which measures how labor market institutions affect the information content of the screening procedures. It is shown that the bargaining game yields two different equilibria depending on this. The main result is that when institutions prevent firms from screening so that the precision of the signal is low, within-group wage dispersion is low, the average wage is high and the unemployment rate is high. On the contrary, when the precision of the signal is accurate, within-group wage dispersion is high, the average wage is low, and the unemployment rate is low. The model also gives the following predictions. Increasing the information content of the screening procedures from the lowerbound to the upperbound of the support of admissible values, shows a jump in within-group wage inequality, but not in the unemployment rate. This jump is the result of a shift in the equilibrium strategies of the game. Further increases to the right of the threshold that triggers the shift strictly decrease the unemployment rate.

In order to test the predictions of the model, using micro-data from the Historical Archive of the Bank of Italy's Survey of Household Income and Wealth, I compute the behavior of the residual wage inequality four years before and after the removal of the system of numeric placement lists, in 1991, for the workers passing through the lists. The pattern of wage inequality shows a jump of about 30% following the reforms of the placement agencies. Within this framework, the jump can be interpreted as the outcome of different equilibrium strategies in the bargaining game, produced by different labor market institutions affecting the information content of the screening procedures.

The results of the paper have also two other important implications. Concerning cross-country differences in residual wage inequality, the model can offer an alternative explanation for the findings of Flinn (2002), who shows that residual wage inequality in 1989 was considerably lower in Italy than in the US. Concerning the behavior of the unemployment rate in Italy, the model can contribute to explain the drop in the unemployment rate that followed the reforms of 1997 and 2003, which enhanced access to temporary contracts.

The paper is organized as follows. Section 2 documents IPS in Italy. The model is presented in Section 3 and it is solved numerically in Section 4. Section 5 presents the empirical evidence, and Section 6 concludes.

2 An interesting example of IPS: the case of Italy

Following WWII, in Italy, the economic inequalities brought about by the war and the spread of the communist ideology sharply oriented the legislator towards the target of social justice. These historical and political considerations, together with the desire to prevent labor exploitation and fraud, explain the creation of Act 264 of 1949, which was, until recent years, the cornerstone of the Italian labor market regulation.[2] In principle, Act 264 of 1949 prevented employers from hiring directly, or through private placement agencies, the workers they needed. Following international labor standards

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[2]See "Temporary Work and Labour Law of the European Community and Member States", 1993, Kluwer Law and Taxation Publishers, Deventer, The Netherlands.

of the time, any private intermediation activity between labor supply and demand was penally forbidden. Firms were therefore obliged to resort to public placement agencies. In the case of manual workers, firms could only make a numerical request to these agencies, specifying the number of workers they needed, while the selection of the workers to be hired was up to the agencies. Job-seekers were sorted into different lists according to their professional category, the so-called *liste di collocamento,* and within each classification they were graded according to their economic need to find a job. This grading had to take into consideration ranking criteria such as the number of children and the family income of the job-seeker. Among two equally graded job-seekers, the one that enrolled first prevailed. If a firm hired workers outside the numerical lists, it would incur in penal and administrative sanctions. Moreover, a labor contract signed between the parties in violation of Act 264 of 1949 was null and void if the local organisms of the Ministry of Labor reported it within a year from the signature. Since 1949, the scope of the act has been partially reduced by a number of additional acts (Act 300 of 1970, Act 79 of 1983, Act 863 of 1984 and Art.17 of Act 56 of 1987) implementing derogations to this rigid system and allowing in some cases for individuals to be specifically requested, rather then derived from the numerical lists. The system of numerical requests was finally abrogated by Act 223 of 1991. It is clear that as long as the firms could not hire workers on the grounds of their ability, they were *de jure* prevented from screening.

The Italian legislator went even further in preventing firms from screening, by limiting both the duration of probation periods and access to temporary contracts. According to the indicators reported by the OECD (1999), by the end of the 1990s the Italian legislation provided for the lowest probation period among all OECD countries. It is very likely that such a short time span hampered the ability of employers to collect relevant information on the productivity of the workers.[3]

As an alternative to hiring on probation for a permanent position, fixed-term contracts can be used by firms to test the ability or the motivation of a worker. In this sense temporary contracts have been considered, in a series of recent papers, as screening devices that are similar to probation. In particular, Varejao and Portugal (2003), in a study on the Portuguese labor market, find that screening workers for permanent positions is the single most important reason why firms use these types of contracts. In general, this view has been supported by strong empirical evidence.[4] The importance of fixed-term contracts as a screening device has been discovered only recently, and its implications at the macro level are not yet clear. However, the new body of empirical evidence looks like a challenge for the standard macroeconomic perspective that has always considered temporary work mainly as an instrument capable of guaranteeing separation at low or zero firing costs.[5] Unlike other countries in Europe, Italy had no specific regulation for temporary work and private placement agencies until the *Treu*

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[3] Ichino and Muelheusser (2004) show that if the length of the probation period is too short, shirkers have an incentive to mimic the behavior of high type workers in order to pass the hiring test. In this case the test is uninformative on workers' characteristics and worthless as a screening device.

[4] See, among many others, Autor (2001), Autor and Houseman (2005), Boockman and Hagen (2005), Houseman (2001), Ichino, Mealli and Nannicini (2004), and Storrie (2002).

[5] Cahuc and Postel Vinay (2002) p.64, write: "It is generally concluded that the introduction of fixed duration contracts is equivalent to the reduction of firing costs and that its impact on unemployment is therefore ambiguous".

law was approved, in 1997.[6] As a result, this reform had an enormous impact on the Italian labor institutions. More recently, with the Act 30 of 14 February 2003, better known as *Legge Biagi*, the regulation of temporary contracts introduced in 1997 was extended to further enhance labor market flexibility.

Given that the institutions above have played a key role in shaping the functioning of the Italian labor market, it is possible to consider them as marking a major institutional difference with respect to US-style labor markets. In the next section a model is presented that embeds these institutions into a standard matching framework.

3 The model

3.1 The economy

The agents:

The economy is characterized by a continuum of identical firms and heterogenous workers, both risk neutral and infinitely lived. The set of workers I has unit measure. Each worker $i \in I$ can be either employed or unemployed and has private information over her type profile, $\lambda_i \in \Lambda$, where $\Lambda = \{l, h\}$ is the space of type profiles, and l and h denote low and high type workers, respectively. A fraction x of workers are low types, and a fraction $1 - x$ are high types. High and low types differ in their productivity, which is denoted by y_λ, and in the opportunity cost of employment, denoted by z_λ, for $\lambda = l, h$. It is assumed that $y_l < y_h$ and $z_l \leq z_h$. It is possible to think about the productivity of high and low types as parameters capturing individual heterogeneity within groups of observationally equivalent workers, i.e., workers with the same profession, education, age, and gender. Both types search in the same labor market.

The labor market is frictional, and firms which want to fill a job post a vacancy. It is assumed that each firm can post one vacancy at most. Labor is the only factor of production, and all agents discount future income at the exogenous rate r. Employment relationships end exogenously at rate q leaving the worker unemployed and the firm with a vacant position.

The matching technology:

The matching process is described by the function $M(v, u)$, which represents the aggregate flow of hires in a unit period. v denotes the measure of vacancies, and u denotes aggregate unemployment, which is the sum of high and low type unemployed workers, denoted, respectively, by u_h and u_l. Time is assumed to be discrete, but since I am only interested in characterizing the behavior of the economy at the stationary equilibrium, I omit the time subscript. The function $M(v, u)$ is assumed to be strictly increasing with respect to each of its arguments and such that $M(v, 0) = M(0, u) = 0$. Lastly, it is assumed that the matching function exhibits constant returns to scale. The probability that a vacancy contacts a worker per every unit of time is:

$$\frac{M(v, u)}{v} = M\left(1, \frac{u}{v}\right) \equiv m(\theta), \qquad \theta \equiv \frac{v}{u},$$

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[6] Act 196 of 24 june 1997, "Norme in materia di promozione dell'occupazione.", Gazzetta Ufficiale n. 154, July 4, 1997 - Supplemento No. 136.

where θ represents the "tightness" of the labor market. The probability that a worker contacts a firm is:

$$\frac{M(v, u)}{u} = \frac{v}{u} \frac{M(v, u)}{v} = \theta m(\theta),$$

and it is assumed to be equal for high and low type workers.

3.2 Workers and Firms

$E_{\lambda_i}(\omega_i)$ denotes the discounted expected income of the worker $i \in I$ of type $\lambda_i \in \Lambda$ employed at wage ω_i, and U_{λ_i} the expected discounted income of the same worker when unemployed. In each period, the employed worker $i \in I$ loses the job with exogenous probability q. At the stationary equilibrium, the flow value of employment for a type λ worker satisfies the following condition, where the subscript i is omitted hereafter for notational clarity:

$$r E_\lambda(\omega) = \omega + q[U_\lambda - E_\lambda(\omega)], \quad \lambda = l, h. \tag{1}$$

Let us denote by $\Omega_\lambda^{\mathtt{w}}$ and $\Omega^{\mathtt{f}}$ the payoff expected upon contact by a worker of type λ and by a firm, respectively. Both of these values will be defined later as the equilibrium outcomes of the bargaining game. The flow value of unemployment for a worker of type λ satisfies:

$$r U_\lambda = z_\lambda + \theta m(\theta)(\Omega_\lambda^{\mathtt{w}} - U_\lambda), \quad \lambda = l, h. \tag{2}$$

c denotes the cost of holding an open vacancy and looking for an employee per unit of time, and V the value of having a vacancy opened. The flow value of a vacancy satisfies the following Bellman equation:

$$r V = -c + m(\theta)\Omega^{\mathtt{f}}.$$

Using the free entry condition, $V = 0$, the expression above can be rewritten as follows:

$$c = m(\theta)\Omega^{\mathtt{f}}, \tag{3}$$

which implies that the expected profits of an entrant firm must equal the expected costs of keeping a vacancy open.

The flow value for the firm of having a worker of type λ employed at wage ω is denoted by $J_\lambda(\omega)$, and satisfies the following equation:

$$r J_\lambda(\omega) = y_\lambda - \omega - q J_\lambda(\omega). \tag{4}$$

3.3 Wage bargaining

It is assumed that wage bargaining is decentralized, and that workers and firms are too small to influence the market wage rate. Wages are set once and for all, and they cannot be conditional on future performance. It is also assumed that firms do not directly observe the productivity of the workers upon matching, but that they know the composition of the unemployment pool and can observe the realization of a signal $\sigma \in \Sigma$, where $\Sigma = \{0, 1\}$ is the set of signals. It is possible to interpret the signal as the outcome of a screening test which workers must take upon contact. We can

think about job interviews, probation periods or temporary contracts as examples of screening tests. When $\sigma = 1$, the worker passes the test, while if $\sigma = 0$ the worker fails. $\pi(\sigma|\lambda)$ denotes the probability that a worker of type λ sends the signal σ. The conditional probability $\pi(\sigma|\lambda)$, for $\sigma \in \Sigma$ and $\lambda \in \Lambda$, can be expressed as a simple function of the parameter $s \in [1/2, 1]$, which represents the precision of the signal:

$$\begin{aligned}
\pi(1|h) &= \pi(0|l) = s &(5)\\
\pi(0|h) &= \pi(1|l) = 1 - s.
\end{aligned}$$

The parameter s is the probability that the test reveals the true type of a worker. When $s = 1/2$, the signal is completely uninformative, while if $s = 1$ the signal reveals perfectly the type of worker. More in general, the higher the value of s, the more informative is the signal. In this framework the exogenous parameter s captures the way institutions affect the predictability of worker types; IPS are associated with relatively low values of s. More in particular, the benchmark case of $s = 1/2$ can be considered as a quite close characterization of the Italian labor market for manual workers in the 1980s, when the system of numerical placement lists prevented *de jure* any screening activity. In this framework, whether the test is useful as a screening device ultimately depends only on labor market institutions.

The timing of the action is the following: wages are bargained at the beginning of the period when a worker and a firm are matched. At the end of the period, production takes place and wages are paid. If the firm makes negative profits the worker is fired and the match is destroyed, while if profits are positive the firm decides to keep the worker.

The bargaining game is the following: Nature moves first, and decides whether the worker with probability γ or the firm with probability $1-\gamma$, makes a take-it or leave-it offer. An interesting feature of the model resulting from this bargaining protocol is that workers with the same productivity may receive different wages at equilibrium, since they might be given different bargaining powers upon matching. The subgame in which the firm makes the offer is denoted by $\Gamma^{\mathtt{f}}$, and the subgame in which the worker makes the offer is denoted by $\Gamma^{\mathtt{w}}$. The next subsections characterize the equilibria of the two subgames restricting attention to equilibria in pure strategies. The extensive form representation of the subgames and all the proofs of the propositions that follow are presented in the Appendix.

3.3.1 The worker makes the take-it or leave-it offer

The structure of this subgame is as follows. First, the type of worker matched is selected with endogenous probabilities $p(\lambda) = u_\lambda/u$, for $\lambda = l, h$. Second, Nature decides whether the signal sent by the worker is 0 or 1, with probabilities given by (5). Third, the worker makes the offer, and fourth, the firm *accepts* or *rejects*. Finally, when production takes place, the firm decides whether to *fire* or *keep* the worker.

Strategies:

I denote by $\omega^{\mathtt{w}} \in \mathbb{R}^+$ a wage offer made by the worker and chosen from the set $\mathbb{R}^+$. A pure strategy for the worker is a map $\omega_\lambda^{\mathtt{w}} : \Lambda \to \mathbb{R}^+$ from her type space Λ to her wage offer space $\mathbb{R}^+$. An equilibrium wage offer for the worker is denoted by $\hat{\omega}_\lambda^{\mathtt{w}}$.

A pure strategy for the firm is a pair of decision rules mapping from its information set to the available actions $a \in A$ and $b \in B$ chosen from the set $A = \{accept, reject\}$ and $B = \{fire, keep\}$ at the relevant information sets. The decision rule $\bar{a} : \mathbb{R}^+ \rightarrow A$ is a mapping from the worker's wage offer space $\mathbb{R}^+$ to the firm's action space A. The decision rule $\bar{b} : \{\mathbb{R}^+, \Lambda\} \rightarrow B$ is a mapping from the worker's wage offer space $\mathbb{R}^+$ and type space Λ to the firm's action space B.

Payoffs:

If the firm *rejects* the offer, the worker gets U and the firm gets zero. If the offer of a worker of type λ is accepted and the worker is not fired at the end of the period, the worker gets $E_\lambda(\omega^{\mathtt{w}})$ and the firm gets $J_\lambda(\omega^{\mathtt{w}})$. If the worker is fired, the firm gets $(y_\lambda - \omega^{\mathtt{w}})/(1+r)$ and the worker gets $(\omega^{\mathtt{w}} + U_\lambda)/(1+r)$.

ASSUMPTION 1: the firm decides to *accept* the wage offer and to *keep* the worker if indifferent.

ASSUMPTION 2:
$$E_l(y_l) \geq (y_h + U_l)/(1+r).$$

If Assumption 2 holds, a low type worker prefers to earn y_l until job destruction occurs exogenously rather than earn y_h for one period only and be successively fired. In section 4, I assign reasonable parameter values to the model and check that this assumption is always satisfied. As I prove formally in the next Proposition, the assumption that the firm can fire workers if profits are negative acts as a credible threat and induces workers to separate their wage offers at equilibrium. As a consequence, the equilibrium strategy for the wage offers of high and low type workers is separating, independently of the precision of the signal s.[7]

Proposition 1 *Suppose Assumption 1 and Assumption 2 hold. Then the wage offers $\hat{\omega}^{\mathtt{w}}_\lambda = y_\lambda$ for $\lambda = l, h$, together with the decisions of the firm to accept both offers and to keep the worker once productivity is revealed is the unique Nash equilibrium of the subgame $\Gamma^{\mathtt{w}}$.*

3.3.2 The firm makes the take-it or leave-it offer

This subgame has the following structure. First, the probabilities $p(\lambda)$ decide the type of worker that is hired. Second, Nature chooses the signal, with probabilities given by (5). Third, the firm makes the offer, and fourth, the worker *accepts* or *rejects*. Finally, at the end of the period, the firm decides whether to *fire* or *keep* the worker.

Strategies:

I denote by $\omega^{\mathtt{f}} \in \mathbb{R}^+$ a wage offer made by the firm and chosen from the set $\mathbb{R}^+$. A pure strategy for the firm is a map $\omega^{\mathtt{f}}(\sigma) : \Sigma \rightarrow \mathbb{R}^+$ from the signal space Σ to the firm's wage offer space $\mathbb{R}^+$ together with a decision rule $\bar{b} : \{\mathbb{R}^+, \Lambda\} \rightarrow B$ mapping

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[7]The condition written in Assumption 2 would not hold if firms were unable to fire workers, or if productivity could only be discovered after a long period of time. Relaxing this assumption would only increase the complexity of the model without changing the qualitative results.

from the firm's wage offer space $\mathbb{R}^+$ and the worker's type space Λ to the firm's action space $B = \{fire, keep\}$. An equilibrium wage offer for the firm is denoted by $\hat{\omega}^{\mathbf{f}}(\sigma)$.

A pure strategy for the worker is a decision rule $\bar{a} : \{\mathbb{R}^+, \Lambda\} \to A$ mapping from the firm's wage offer space $\mathbb{R}^+$ and the worker's type space Λ to the worker's action space $A = \{accept, reject\}$.

Payoffs:
Payoffs follow the same structure as in the subgame $\Gamma^{\mathbf{w}}$.

Beliefs:
The firm uses Bayes' rule to update its prior beliefs, which are given by the matching probabilities. The firm's posterior beliefs, conditional on the observation of the signal are:

$$\mu(\lambda|\sigma) = \frac{p(\lambda)\pi(\sigma|\lambda)}{\displaystyle\sum_{\lambda'=l,h} p(\lambda')\pi(\sigma|\lambda')}. \tag{6}$$

ASSUMPTION 3: workers *accept* the wage offer if indifferent.

ASSUMPTION 4:
$$y_l \geq rU_h.$$

ASSUMPTION 5:
$$U_h > U_l.$$

Assumption 4 imposes a restriction on the choice of the parameters y_h and y_l. Since rU_h strictly increases with y_h at equilibrium, Assumption 4 imposes an upper bound on the difference between y_h and y_l. This assumption ensures that the surplus created by a match be positive when the wage $\hat{\omega}^{\mathbf{f}}(\sigma) = rU_h$ is offered to a low type worker. If Assumption 4 holds, the firm's option to fire workers is never exercised at equilibrium, and therefore a match can only break down for exogenous reasons.

Assumption 5 does not impose any parametric restriction. When the model is solved numerically, I check that this assumption is satisfied for all the parameter values that support an equilibrium solution.

The economic intuition for the bargaining problem of the firm is the following. When information is perfect, i.e., $s = 1$, the outcome of the test perfectly reveals the type of a worker. If this is the case, when the firm makes the offer, a worker of type λ gets rU_λ, which is the lowest wage she is willing to accept. When instead information is incomplete, the outcome of the screening test is no longer perfectly correlated with with the type of the worker. Under this scenario the firm has to compare expected costs and benefits associated with each offer. If the low wage rU_l is offered, the firm enjoys high future profits $J_l(rU_l)$ if the type of worker receiving the offer is low, but it forgoes any profit if the type of the worker turns out to be high. This follows since it is optimal for a high type worker to reject any offer lower than rU_h. If instead the high wage rU_h is offered, the firm enjoys lower future profits $J_l(rU_h)$ if the worker is low, but it still makes positive profits $J_h(rU_h)$ if the worker is high. To put it differently, the firm trades-off insurance against the breakdown of wage negotiations with high type workers versus higher future profits with low type workers. Conditional on the

observation of the signal, it will be therefore optimal for the firm to offer rU_h whenever the following condition holds:

$$\mu(h|\sigma)J_h(rU_h) \geq \mu(l|\sigma)\left[J_l(rU_l) - J_l(rU_h)\right], \tag{7}$$

where the l.h.s. represents the expected gains from insurance and the r.h.s. represents the opportunity cost of offering rU_h. Whether condition (7) holds or not depends, in general, on the distribution of worker types in the unemployment pool, on the outcome of the test, and on the precision of the signal.

Proposition 2 *Suppose Assumption 1, Assumption 3, Assumption 4 and Assumption 5 hold. Then the wage offer $\hat{\omega}^{\mathbf{f}}(\sigma) = rU_h$, together with the conditional posterior beliefs system in (6), the decision to accept for both low and high type workers, and the firm's decision to keep the worker, is the unique Bayesian-Nash equilibrium of the subgame $\Gamma^{\mathbf{f}}$ for any $\sigma \in \Sigma$ such that condition (7) holds.*

Proposition 3 *Suppose Assumption 3, Assumption 4 and Assumption 5 hold. Then the wage offer $\hat{\omega}^{\mathbf{f}}(\sigma) = rU_l$, together with the conditional posterior beliefs system in (6), the low type worker's decision to accept, the high type worker's decision to reject, and the firm's decision to keep the worker, is the unique Bayesian-Nash equilibrium of the subgame $\Gamma^{\mathbf{f}}$ for any $\sigma \in \Sigma$ such that condition (7) fails to hold.*

3.3.3 The solutions of the bargaining game as a function of s

This section investigates how the equilibria of the whole game change with the quality of information embodied in the signal. Since the equilibrium of the subgame $\Gamma^{\mathbf{w}}$ is independent of s, a change in the equilibrium of the whole bargaining protocol can only follow from a change in the equilibrium of the subgame $\Gamma^{\mathbf{f}}$. I contrast the case in which the signal is uninformative with the case in which the signal is perfectly informative and I show that the bargaining game exhibits different equilibria. These two equilibria are characterized with the payoffs expected by the players upon engaging in the bargaining game and with the flows in and out of the unemployment pool. Section 4 then shows numerically that for all the reasonable parameter values supporting an equilibrium solution there exists a unique threshold value of s, denoted by s^*, such that the bargaining game exhibits two different sets of equilibrium strategies, one for $s \in [1/2, s^*]$, and another for $s \in (s^*, 1]$.

CASE 1 The signal is uninformative: $s = 1/2$.

By (5) and (6), if $s = 1/2$, $\mu(\lambda|\sigma) = p(\lambda)$ for $\lambda = l, h$. When the signal is uninformative the firm's beliefs are given by the matching probabilities and are therefore independent of the realization of σ. Consequently, also condition (7) must be independent of σ. The next section shows that condition (7) is always satisfied for $s = 1/2$ when reasonable parameter values are assigned to the model. The equilibrium wage offer of the firm is therefore pooling when $s = 1/2$, with the firm offering $\hat{\omega}^{\mathbf{f}}(\sigma) = rU_h$ for both $\sigma = 0, 1$.

Proposition 4 *Suppose condition (7) holds for both $\sigma = 0, 1$. Then a matched worker is of type λ with probability:*

$$p(\lambda) = x_\lambda.$$

When the signal is uninformative both types of workers enter and exit from the unemployment pool at the same rates. This has two implications. The first is that the relative measure of type λ workers in the unemployment pool is equal to their relative measure in the labor force, x_λ. The second is that the equilibrium unemployment rate is the same for high and low type workers.

We are now ready to characterize the expected payoffs for workers and firms when $\hat{\omega}^{\mathbf{f}}(\sigma) = rU_h$ is offered to a worker independently of the outcome of the test, σ.

Proposition 5 *Suppose condition (7) holds for both $\sigma = 0, 1$. Then a worker of type λ expects a payoff*

$$\Omega_\lambda^{\mathbf{w}} = [\gamma y_\lambda + (1 - \gamma) rU_h + qU_\lambda] / (r + q)$$

upon engaging in the bargaining game, and the firm expects

$$\Omega^{\mathbf{f}} = (1 - \gamma) [(1 - x) y_h + x y_l - rU_h] / (r + q).$$

In the next section we will see that condition (7) holds in the interval of $s \in [1/2, s^*]$ for both $\sigma = 0, 1$. The equilibrium of the labor market is therefore described by equations (1) to (4) together with the equations in Proposition 5 whenever $s \in [1/2, s^*]$.

CASE 2 The signal is perfectly informative: $s = 1$.

It is easy to show that when $s = 1$ condition (7) holds for $\sigma = 1$ but does not hold for $\sigma = 0$. Substituting (4) into (7), condition (7) can be rewritten as follows:

$$\mu(h|\sigma)(y_h - rU_h) - \mu(l|\sigma)(rU_h - rU_l) \geq 0 \quad for \ \sigma \in \Sigma.$$

By (6) and (5) $\mu(h|1) = \mu(l|0) = 1$ and $\mu(l|1) = \mu(h|0) = 0$ for $s = 1$. Then (7) is satisfied for $\sigma = 1$ since $y_h > y_l$, and $y_l \geq rU_h$ by Assumption 4. On the contrary, when $\sigma = 0$ condition (7) fails to hold by Assumption 5. The equilibrium wage offer of the firm is therefore separating when $s = 1$, with the firm offering $\hat{\omega}^{\mathbf{f}}(1) = rU_h$ and $\hat{\omega}^{\mathbf{f}}(0) = rU_l$.

Proposition 6 *Suppose condition (7) holds for $\sigma = 1$ but does not hold for $\sigma = 0$. Then the probability that a low and a high type worker contacts a firm is $p(\lambda) = u_\lambda/u$ for $\lambda = l, h$, where*

$$u_l = \frac{qx_l}{q + \theta m(\theta)}$$

$$u_h = \frac{qx_h}{q + \theta m(\theta)[\gamma + (1 - \gamma)s]}.$$

By Proposition 6 it is possible to note that when $s = 1$ the unemployment rate u_λ/x_λ is identical for both high and low type workers. For every value of $s \in (s^*, 1)$ such that condition (7) holds only for $\sigma = 1$, the unemployment rate will be higher for high than for low type workers. When the signal is relatively informative high type workers who send the bad signal *reject* the wage offer. Therefore, they search more than low type workers, on average, who *accept* any wage offer at equilibrium independently of the outcome of the screening test.

We can now characterize the expected payoffs for workers and firms when the wage offer is conditional to the outcome of the screening test, so that a worker gets rU_h upon passing the test, and rU_l otherwise.

Proposition 7 *Suppose condition (7) holds for $\sigma = 1$ but does not hold for $\sigma = 0$. Then a worker of type h expects a payoff*

$$\Omega_h^{\mathtt{W}} = \left[\gamma y_h + (1 - \gamma) r U_h + q U_h\right] / (r + q)$$

upon engaging in the bargaining game, a worker of type l expects a payoff

$$\Omega_l^{\mathtt{W}} = \left[\gamma y_l + s (1 - \gamma) r U_l + (1 - s)(1 - \gamma) r U_h + q U_l\right] / (r + q)$$

and the firm expects

$$\Omega^{\mathtt{f}} = (1 - \gamma) \left[p(h)s(y_h - rU_h) + p(l)s(y_l - rU_l) + p(l)(1 - s)(y_l - rU_h)\right] / (r + q).$$

By Proposition 7 it is possible to note that in the special case in which $s = 1$, when information is perfect the average wage bargained by a worker of type $\lambda = l, h$, $\gamma y_\lambda + (1 - \gamma) r U_\lambda$, is the outcome of the generalized Nash criterion. When the model is solved numerically in the next Section, we will see that condition (7) holds for $\sigma = 1$ but does not hold for $\sigma = 0$ in the interval of $s \in (s^*, 1]$. The equilibrium of the labor market is therefore described by equations (1) to (4) together with the equations in Proposition 6 and Proposition 7 whenever $s \in (s^*, 1]$.

4 Numerical analysis

In this section numerical values are assigned to the model in order to analyze how the equilibrium of the labor market is affected by a change in labor market institutions. The parameters used for the exercise are reported in the table below.

y_h	y_l	x	r	c	γ	q	z_λ	α
.53	.47	.5	.025	.3	.5	.1	$.4y_\lambda$	.5

Table 1: Benchmark parameter values

One unit of time in the model equals one quarter. Average productivity is normalized to .5, and both types of workers are assumed to be equally distributed, so that $x = .5$. The spread between high and low productivity is set arbitrarily, without any effect on qualitative considerations. In line with the vast majority of studies, the matching process is represented by a Cobb-Douglas function, written $M(v, u) = u^\alpha v^{1-\alpha}$. The elasticity of the matching function with respect to unemployment is assumed to be $\alpha = .5$, as in Mortensen and Pissarides (1999). The bargaining power of the workers is selected to respect the Hosios condition, and so $\gamma = .5$. Following Shimer (2005), the income value of an unemployed worker equals 40% of her productivity. Quarterly job destruction is set to $q = .10$ as in Shimer (2005), and the cost of a vacancy is $c = .3$. The quarterly interest rate is set to .025 as in Italy during the late '80s.

Numerical solutions of the model show that the game exhibits two sets of equilibrium strategies satisfying assumptions 1 to 5. The equilibrium of the subgame $\Gamma^{\mathtt{f}}$ is pooling when the precision of the signal is low and $s \in [1/2, s^*]$, with the firm offering $\hat{\omega}^{\mathtt{f}}(\sigma) = rU_h$ for both $\sigma = 0, 1$; the equilibrium is separating when the precision of the

signal is high and $s \in (s^*, 1]$, with the firm offering rU_h when $\sigma = 1$, and rU_l when $\sigma = 0$. The intuition for the result is the following: so long as the screening device is not sufficiently reliable, i.e., s is below the threshold, it is not profitable for the firm to condition the wage offer to the outcome of the test. If a firm offers a high type worker a wage equal to the outside option of a low type worker, the match breaks down, and its surplus is wasted. Therefore, the firm will not offer rU_l unless it perceives that the probability of facing a low type worker is sufficiently high. This can only happen if the worker fails the test, and if the test is sufficiently informative about the type of the worker, that is, if s is high enough. The equilibrium of the subgame $\Gamma^{\mathtt{W}}$ is instead independent of s, so that a worker of type λ is paid y_λ whenever she makes the offer.

The equilibrium of the labor market in terms of wages, unemployment rates and wage dispersion is reported in Figure 1 in the Appendix for the parameter values in Table 1 and for $s \in [1/2, 1]$. For every value of s, I computed the standard deviation of wages as an index of wage dispersion. Given the benchmark parametrization, all the parameter values were changed one at a time as a robustness check for the qualitative results. The results proved robust to all the changes which support an equilibrium solution and I summarize them below.

1. When the precision of the signal is relatively low so that information is noisy, wages are more compressed and unemployment rates are high; when the precision of the signal is relatively high, information is accurate, wages are more dispersed, and unemployment rates are low. A trade-off emerges between unemployment and wage inequality, which is produced only by the quality of information.

2. When the quality of information embedded in the signal is very low, small variations in s have no impact on the labor market equilibrium. Given the baseline parametrization, firms condition their wage offer to the outcome of the test provided that the signal reveals the true type of the worker with a probability higher than 74%. At any lower degree of precision, the signal is considered as uninformative.

3. The average wage drops at the threshold s^* and strictly decreases with the precision of the signal in the interval of $s \in (s^*, 1]$. For values of s below the threshold, both types of workers receive rU_h when the firm makes the offer. To the right of the threshold, low type workers receive a wage offer equal to rU_h only if they pass the test, and get rU_l otherwise. Since $U_l < U_h$, the shift in the equilibrium strategies played by the firm explains why the average wage drops at the threshold. This effect largely dominates the following counteracting effect: while all wage negotiations succeed for $s \in [1/2, s^*]$, to the right of s^* instead, negotiations fail whenever the firm offers rU_l to a high type worker who failed the test. Therefore, at the threshold the fraction of high type employed workers who receive y_h is higher than to the left of s^*. This effect tends to increase the average wage, although its quantitative importance is relatively minor. To the right of the threshold, both the fraction of low type workers receiving rU_l, and the fraction of high type workers receiving rU_h increase with the precision of the signal. Both effects therefore contribute to lower the average wage to the right of the threshold.

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4. The value of search for a low type worker drops at s^* and its behavior is ambiguous to the right of s^*. As the equilibrium strategies played by the firm change at the threshold, low type workers expect to receive lower wages upon contact, and their value of search drops. Further increases in the precision of the signal decrease the expected wage even more, but increase the tightness of the labor market and the exit rate from unemployment so that the two effects offset each other. When the equilibrium strategies played by the firm change at the threshold, high type workers expect a higher rate of break-down in the wage negotiations but the same value of the match, since they are indifferent between working at the wage rU_h or searching in the labor market. The value of search for a high type worker strictly increases to the right of s^* since the exit rate from unemployment strictly increases with s.

5. At the threshold s^* it is possible to observe a strong discrete change both in wage dispersion and in the average wage, but not in the unemployment rate. While wage dispersion jumps and the average wage drops at the threshold as a direct consequence of the change in the equilibrium strategies played by the firm, the behavior of the unemployment rate at s^* is ambiguous since it is driven by two offsetting forces. The decrease in the average wage tends to increase the value of opening a vacancy, but the increase in the failing rate of the wage negotiations tends to decrease it. Further increases in s, instead, decrease both the average wage and the rate of break-down of the wage negotiations with high type workers. Therefore, the unemployment rate decreases without ambiguity at the right of s^*, although the average productivity of the workers in the unemployment pool decreases with s, since high type workers exit unemployment at a higher rate. To the right of the threshold the behavior of wage dispersion is in general ambiguous, and depends on the parametric specification of the model. As the precision of the signal increases, the increase in spread between the wage offers rU_h and rU_l tends to increase wage dispersion. On the other hand, as the rate of break-down in the wage negotiations with high type workers decreases with s, a lower fraction of high type workers is employed at the wage y_h, and a higher fraction is employed at the wage rU_h. This effect tends to decrease wage dispersion. As a result, the index of wage dispersion is roughly constant to the right of s^*.

6. When the precision of the signal is relatively high, $s \in (s^*, 1)$, the unemployment rate is higher for high type than for low type unemployed workers. Intuitively, when the test is relatively informative on the nature of worker types, high type workers who fail the screening test prefer to reject the low wage offer and look for a new wage offer. For both types of workers the unemployment rates are strictly decreasing with the precision of the signal since an increase in the efficiency of the bargaining process increases the profits expected upon entry and the matching probability. The unemployment rate is decreasing faster for high type workers since an increase in s decreases their failing rate in the screening test and increases their rate of exit from the unemployment pool. In the particular case in which $s = 1$, information is perfect, and both types of workers flow out of the unemployment pool at the same rate.

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The next section presents some empirical evidence which is consistent with the predictions of the model.

5   Empirical Evidence

The main result of the model is that when individual heterogeneity is no longer predictable at the time of bargaining, the unemployment rate is higher and wage compression arises endogenously within groups of observationally equivalent workers. Since IPS clearly characterized the Italian labor market with respect to the US labor market, the model can then offer an alternative explanation about why within-group wage inequality was much lower in Italy than in the US, as measured by Flinn (2002), using sample data of 1989.

Simulations of the model for the values of $s \in [1/2, 1]$ show that increasing the precision of the signal, from the lowerbound to the upperbound of the support, leads to a jump in wage dispersion. Given that this jump reflects the increased ability for the firms to extract information on the unobservable characteristics of the workers, what should be observed in the data is a jump in residual wage inequality following a major increase in the precision of signal extraction, provided that the initial condition for s is "low enough". A natural candidate for this type of reform is the abolition of the system of numerical placement lists, as seen in 1991.

The micro-data from the Historical Archive of the Bank of Italy's Survey of Household Income and Wealth (SHIW) that allows for the computation of hourly wages is available only after 1987. Survey data are collected every two years from 1987 to 1995. Since the next survey available after 1995 is 1998, which is after the new wave of reforms that took place in 1997, I restrict attention to the symmetric time interval of four years before and after the reform of 1991, the period 1987-1995.

I consider only full-year manual workers. Hourly wages are computed using information on gross yearly income and average weekly hours worked, and assuming 48 working weeks per year. Real hourly wages are then obtained by deflating the nominal hourly wages with the base 1991 CPI. I further restrict the sample to the category of workers who are less than 30 years of age, for whom the likelihood of observing new entry-level bargained wages is higher. The sample consists of approximately 4000 observations. Real hourly wages are then regressed on a set of observable characteristics such as age, education, gender and regional area, using dummy variables also for part-time jobs and survey years. The standard deviation of the residuals, reported in Figure 2 in the Appendix by year, shows a jump of about 30% following the removal of the numerical placement system in 1991. These findings seem consistent with the predictions of the model.

However, other explanations could potentially be compatible with this behavior of residual wage inequality, such as the abolition in the early 1990s of the *scala mobile*, a wage indexation mechanism granting the same absolute wage increase to all employees as prices rose. It is generally believed that starting from the 1970s, the *scala mobile* played an important role in shaping the behavior of wage inequality in Italy. Yet, the *scala mobile* hypothesis seems hard to reconcile with the jump in Figure 2 since, as shown in a study by Manacorda (2004), already by the mid-1980s this indexation mechanism had ceased to produce any equalizing effect.

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As described in section 2, the reforms of 1997 and 2003 were important in favoring further access to screening devices by regulating temporary contracts. The model predicts that these reforms would be followed by a decrease in the unemployment rate. The pattern of the data is also consistent with these predictions: the unemployment rate started to decrease in 1997, from 11.3%, to reach 6.8% in 2006. Furthermore, the unemployment rate steadily decreased in this period, even during downturns in economic activity.

6   Conclusions

The microeconomic literature in personnel economics has thoroughly investigated the importance of screening procedures such as job interviews, probationary periods and temporary contracts in the firms' hiring policies. Yet, labor market institutions can affect these hiring policies by either preventing firms from testing the workers or by making the test ineffective as a screening device. In the case of Italy, these institutions played a central role in the functioning of the labor market. This paper embeds such institutions into a standard matching model to analyze their macroeconomic consequences. The main finding is that by preventing firms from screening workers, these institutions can reduce inequality among observationally equivalent workers, at the cost of higher unemployment rates. The model therefore offers an explanation for the well-documented trade-off between unemployment and wage inequality. It also identifies, in the institutions affecting the information content of the screening procedures, a determinant of within-group wage inequality.

These results were obtained under standard assumptions on the bargaining protocol. Following the literature on bargaining with asymmetric information, it was assumed that either the worker or the firm makes a take-it or leave-it offer. Beyond ensuring tractability, this assumption allows for the recovery of the Nash bargaining solution for the limit case of perfect information. It is possible, though, that alternative bargaining protocols might induce truth-telling equilibrium strategies for the workers, which can undue the perverse effects of asymmetric information. Pursuing mechanism designs in this framework is beyond the scope of this paper and is left for future research.

This paper takes a first step towards understanding the macroeconomic impact of labor market institutions influencing firms' screening activity. Such institutions cover a wide range of rules and regulations governing disparate juridical issues such as probation periods, the space for possible contractual arrangements or the functioning of employment placement agencies. All these institutions were condensed through the modeling strategy into a single parameter representing the precision of the screening procedures. Although this allows for the development of a simple framework to derive general conclusions, more specific modeling of institutions might help uncover, in future studies, new mechanisms through which information affects the labor market equilibrium.

A Appendix

Proof of Proposition 1.   By backward induction. When making the offer the worker knows that the best response of the firm is to *fire* her if profits are negative. Then, a low type worker would not offer more than y_l by Assumption 2. Furthermore, a high type worker would not offer more than y_h since the firm would *reject*. Since the firm knows that the wage offer y_h could only come from a high type, the firm would accept such an offer by Assumption 1. Therefore, it would not be optimal for a high type worker to offer any wage lower than y_h. Since the wage offer $\omega_h^{\mathtt{w}} = y_h$ strictly dominates all other possible wage offers for a high type worker, the firm knows that the offer y_l can only come from a low type worker, and would therefore *accept* it by Assumption 1. Thus, a low type worker would not offer less than y_l, and therefore the wage offer $\omega_l^{\mathtt{w}} = y_l$ strictly dominates all other possible offers. The wage offers $\hat{\omega}_\lambda^{\mathtt{w}} = y_\lambda$ therefore define the unique Nash equilibrium of this subgame together with the decision of the firm to *accept* such offers, and the decision to *keep* the worker. ■

  Proof of Proposition 2.   By backward induction. When making the offer, the firm knows that for a worker of type $\lambda = l, h$ the best response is to *accept* any wage offer $\omega^{\mathtt{f}} : E_\lambda\left(\omega^{\mathtt{f}}\right) \geq U_\lambda$, where the equality sign follows from Assumption 3. Then, by eq.(1) a worker of type λ *accepts* any offer $\omega^{\mathtt{f}} \geq rU_\lambda$ and otherwise *rejects*. By Assumption 5, while both types of workers *accept* the offer $\omega^{\mathtt{f}} = rU_h$, only low type workers *accept* the offer $\omega^{\mathtt{f}} = rU_l$. Since the value of a job filled with a worker of type λ, J_λ in eq.(4), strictly decreases with the wage, given the best response of the worker, the firm would never offer any $\omega^{\mathtt{f}}(\sigma) > rU_h$. By Assumptions 4 the firm knows that whatever is the type of worker receiving an offer $\omega^{\mathtt{f}}(\sigma) \leq rU_h$, profits will be non-negative and the firm will *keep* the worker by Assumption 1. If condition (7) holds for a given realization of σ, the profits expected from the offer rU_h, which both types of workers *accept*, are higher than the profits expected from the offer rU_l, which only low type workers *accept*. Consequently, it must be that the profits expected from $\omega^{\mathtt{f}}(\sigma) = rU_h$ are higher than the profits expected from any $\omega^{\mathtt{f}}(\sigma) < rU_h$. If this is the case, $\hat{\omega}^{\mathtt{f}}(\sigma) = rU_h$ is the unique optimal wage offer for the firm given the best response of the worker and the system of beliefs in eq.(6), for each value of σ that satisfies condition (7). This wage offer together with the Bayesian system of beliefs, the decision of the workers to *accept* the offer, and the decision of the firm to *keep* the worker therefore define the unique Bayesian-Nash equilibrium of this subgame provided that condition (7) is satisfied. ■

  Proof of Proposition 3.   The Proof follows the same steps of the previous one. By Assumption 3 and eq.(1) the best response for a worker of type $\lambda = l, h$ is to *accept* any wage offer $\omega^{\mathtt{f}} \geq rU_\lambda$ and otherwise *reject*. If condition (7) fails to hold, the profits expected from the offer rU_h which both types of workers *accept*, is lower than the profits expected from the offer rU_l, which only low type workers *accept*. Since $J_\lambda\left(\omega\right)$ is strictly decreasing in the bargained wage it follows that, for a given realization of σ, the wage offer $\hat{\omega}^{\mathtt{f}}(\sigma) = rU_l$ is optimal and unique given the best response of the workers and the Bayesian updating of beliefs. By Assumption 4 and Assumption 5 whatever is the type of worker receiving the equilibrium offer rU_l, profits are strictly positive, and it is optimal for the firm to *keep* the worker. ■

  Proof of Proposition 4. If condition (7) holds for both $\sigma = 0, 1$, by Proposition

1 and Proposition 2 all agents *accept* the wage offer at equilibrium. Both types of workers therefore exit unemployment at rate $\theta m\left(\theta\right)$. At the stationary state, when job creation equals job destruction, $q\left(x_\lambda - u_\lambda\right) = \theta m\left(\theta\right) u_\lambda$. From the former, $u_\lambda = qx_\lambda / \left[q + \theta m\left(\theta\right)\right]$. Since the probability that a matched worker is of type λ equals $p\left(\lambda\right) = u_\lambda / u$, substituting the expression for u_λ yields $p\left(\lambda\right) = x_\lambda$. ∎

Proof of Proposition 5. By Proposition 2 the equilibrium wage offer of the subgame $\Gamma^{\mathbf{f}}$ is $\hat{\omega}^{\mathbf{f}}(\sigma) = rU_h$ for both $\sigma = 0, 1$. By Proposition 1 the equilibrium wage offer of the subgame $\Gamma^{\mathbf{w}}$ is $\hat{\omega}^{\mathbf{w}}_\lambda = y_\lambda$ for both $\lambda = l, h$. Then, using eq.(1) the expected payoff of the whole game for a worker of type $\lambda = l, h$ is:

$$
\begin{aligned}
\Omega^{\mathbf{w}}_\lambda &= \gamma E_\lambda\left(y_\lambda\right) + \left(1 - \gamma\right) E_\lambda\left(rU_h\right) = \\
&\quad \left[\gamma y_\lambda + \left(1 - \gamma\right) rU_h + qU_\lambda\right] / \left(r + q\right).
\end{aligned}
$$

By Proposition 1, Proposition 2 and Proposition 4, and making use of eq.(4), the expected payoff of the whole game for the firm is:

$$
\begin{aligned}
\Omega^{\mathbf{f}} &= \left(1 - \gamma\right)\left[p\left(h\right) J_h\left(rU_h\right) + p\left(l\right) J_l\left(rU_h\right)\right] = \\
&\quad \left(1 - \gamma\right)\left[\left(1 - x\right) y_h + xy_l - rU_h\right] / \left(r + q\right).
\end{aligned}
$$

∎

Proof of Proposition 6. By Proposition 1, Proposition 2 and Proposition 3, a low type worker is matched any time she contacts a firm. Low type workers therefore exit from the unemployment pool at rate $\theta m\left(\theta\right)$. The equilibrium of flows implies that $q\left(x_l - u_l\right) = \theta m\left(\theta\right) u_l$, which can be rearranged as $u_l = qx_l / \left[q + \theta m\left(\theta\right)\right]$. By Proposition 1, Proposition 2 and Proposition 3, the contact between a high type worker and a firm results in a match any time the worker makes the offer and when the firm makes the offer and the worker sends the signal $\sigma = 1$, with probability s. A high type worker therefore exits unemployment at rate $\theta m\left(\theta\right)\left[\gamma + \left(1 - \gamma\right) s\right]$. When job creation equals job destruction it must be that $q\left(x_h - u_h\right) = \theta m\left(\theta\right)\left[\gamma + \left(1 - \gamma\right) s\right] u_h$, which can be rewritten: $u_h = qx_h / \left\{q + \theta m\left(\theta\right)\left[\gamma + \left(1 - \gamma\right) s\right]\right\}$. ∎

Proof of Proposition 7. By Propositions 2 and Proposition 3, it must be that $\hat{\omega}^{\mathbf{f}}(1) = rU_h$, and $\hat{\omega}^{\mathbf{f}}(0) = rU_l$. By Proposition 1, $\hat{\omega}^{\mathbf{w}}_\lambda = y_\lambda$. Using (1) it is possible to write the payoff expected by a high and a low type worker upon contact as:
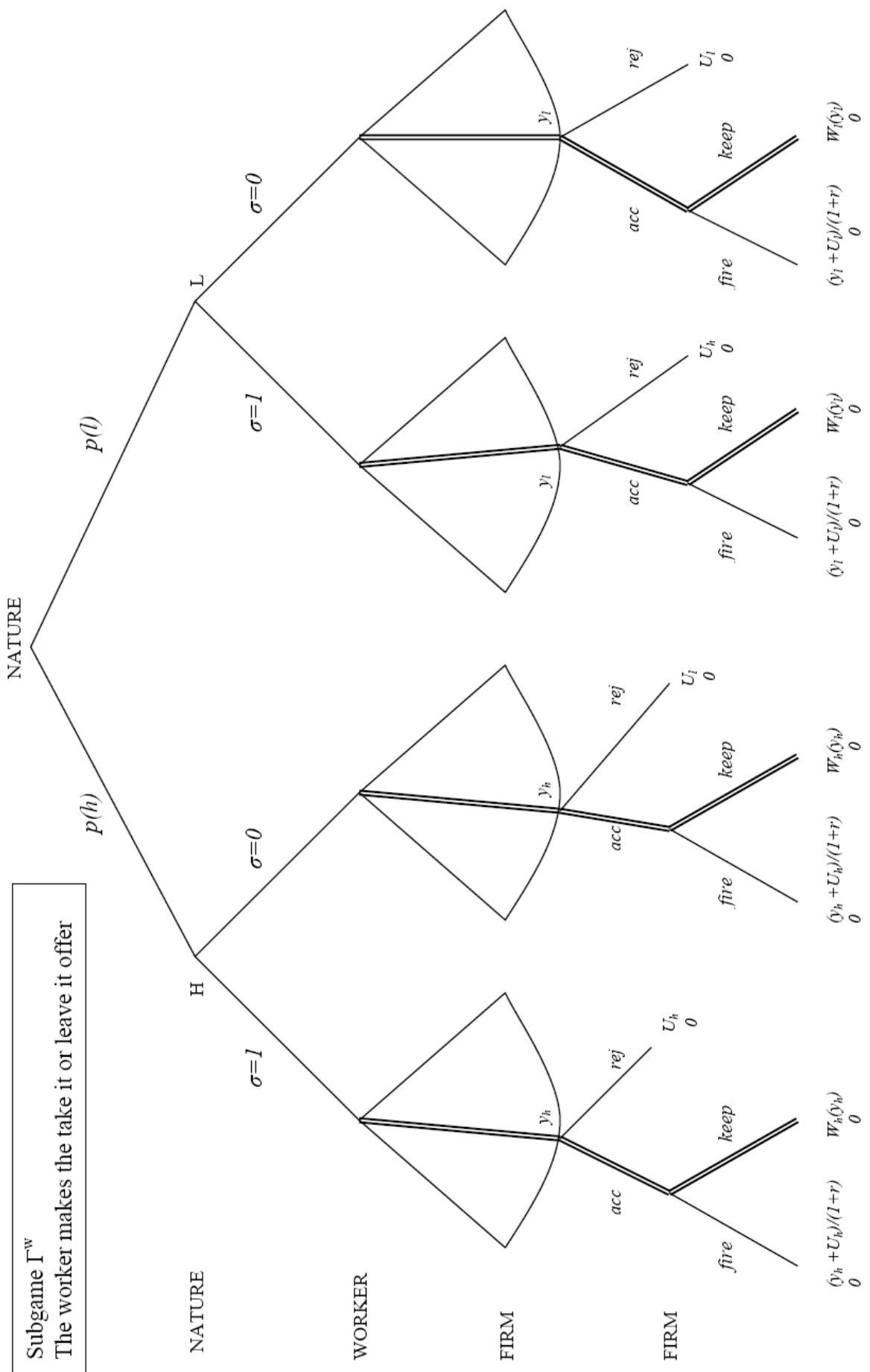
$$
\begin{aligned}
\Omega^{\mathbf{w}}_h &= \gamma E_h\left(y_h\right) + \left(1 - \gamma\right)\left[sE_h\left(rU_h\right) + (1 - s)U_h\right] = \\
&\quad \left[\gamma y_h + \left(1 - \gamma\right) rU_h + qU_h\right] / \left(r + q\right),
\end{aligned}
$$

$$
\begin{aligned}
\Omega^{\mathbf{w}}_l &= \gamma E_l\left(y_l\right) + \left(1 - \gamma\right)\left[sE_l\left(rU_l\right) + (1 - s) E_l\left(rU_h\right)\right] = \\
&\quad \left[\gamma y_l + s\left(1 - \gamma\right) rU_l + \left(1 - s\right)\left(1 - \gamma\right) rU_h + qU_l\right] / \left(r + q\right).
\end{aligned}
$$

Using (4), the payoff expected by the firm is:

$$
\begin{aligned}
\Omega^{\mathbf{f}} &= \left(1 - \gamma\right)\left[p\left(h\right) sJ_h\left(rU_h\right) + p\left(l\right) sJ_l\left(rU_l\right) + p\left(l\right)\left(1 - s\right) J_l\left(rU_h\right)\right] = \\
&\quad \left(1 - \gamma\right)\left[p(h)s(y_h - rU_h) + p(l)s(y_l - rU_l) + p(l)(1 - s)(y_l - rU_h)\right] / \left(r + q\right).
\end{aligned}
$$

∎

Subgame Γ^w
The worker makes the take it or leave it offer

NATURE

$p(l)$

$p(h)$

L

H

NATURE

$\sigma=0$

$\sigma=1$

$\sigma=0$

$\sigma=1$

WORKER

y_l

y_l

y_h

y_h

FIRM

rej

U_l
0

rej

U_h
0

rej

U_l
0

rej

U_h
0

acc

acc

acc

acc

FIRM

$keep$

$W_l(y_l)$
0

$keep$

$W_l(y_l)$
0

$keep$

$W_h(y_h)$
0

$keep$

$W_h(y_h)$
0

$fire$

$(y_l+U_l)/(1+r)$
0

$fire$

$(y_l+U_l)/(1+r)$
0

$fire$

$(y_h+U_h)/(1+r)$
0

$fire$

$(y_h+U_h)/(1+r)$
0

Subgame Γ^f
The firm makes the take it or leave it offer

NATURE

$p(h)$ $p(l)$

H   L

NATURE

$\sigma=1$ $\sigma=0$ $\sigma=1$ $\sigma=0$

FIRM

$\omega^f(1)$ $\omega^f(0)$ $\omega^f(1)$ $\omega^f(0)$

WORKER

rej U_h 0

acc

rej U_h 0

acc

rej U_h 0

acc

rej U_l 0

acc

FIRM

fire   keep   fire   keep   fire   keep   fire   keep

$(\omega^f(1)+U_h)/(1+r)$ $W_h(\omega^f(1))$
$(y_h-\omega^f(1))/(1+r)$ $J_h(\omega^f(1))$

$(\omega^f(0)+U_h)/(1+r)$ $W_h(\omega^f(0))$
$(y_h-\omega^f(0))/(1+r)$ $J_h(\omega^f(0))$

$(\omega^f(1)+U_l)/(1+r)$ $W_l(\omega^f(1))$
$(y_l-\omega^f(1))/(1+r)$ $J_l(\omega^f(1))$

$(\omega^f(0)+U_l)/(1+r)$ $W_l(\omega^f(0))$
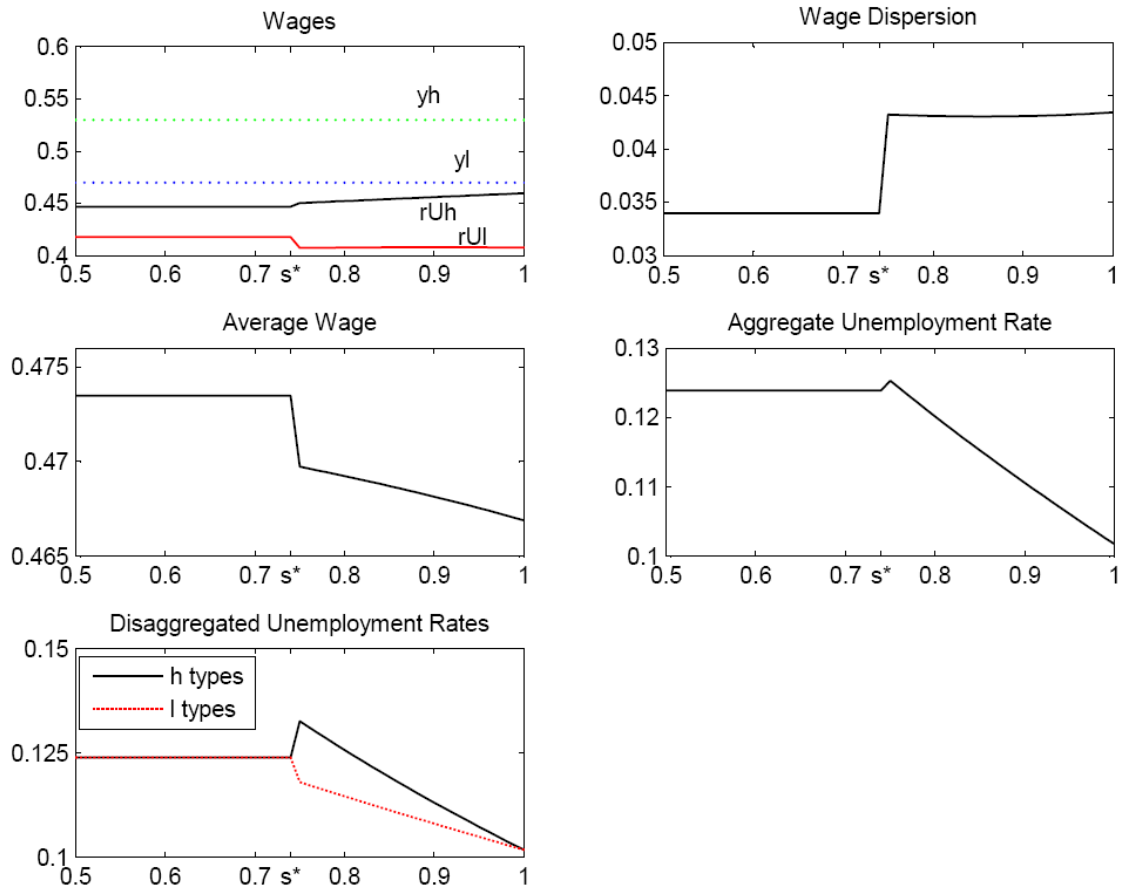$(y_l-\omega^f(0))/(1+r)$ $J_l(\omega^f(0))$

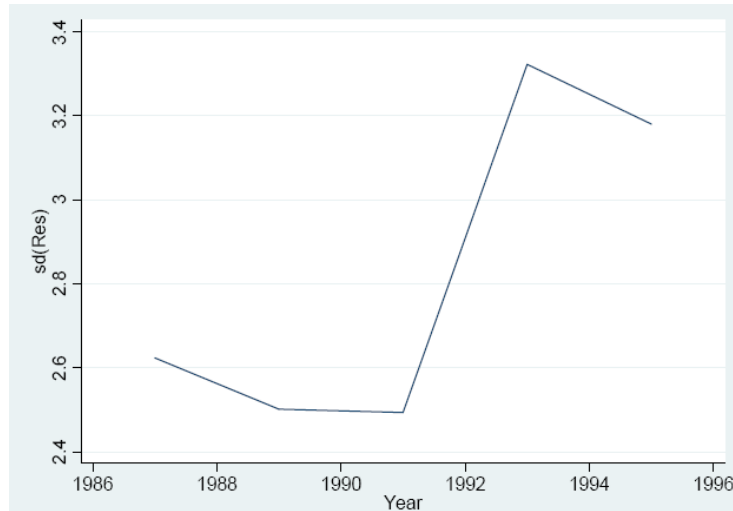Figure 1: Simulation results for the parameter values in Table 1.

Figure 2: Residual wage dispersion for full-year manual workers younger than 30 years of age in Italy. Author's calculations from the SHIW panel of the Bank of Italy.

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