Industry profits, wages and competition under incentive labour contracts with unverifiable effort

Nicola Meccheri and Luciano Fanti*

Department of Economics, University of Pisa, Italy

November 2010

Abstract

This paper studies the interaction between incentive labour contracts, competition *à la* Cournot and industry profits, in a context where workers' effort is not verifiable and the probability of the unemployed getting a job can depend on their employment histories according to the degree of product market competition. It is shown that efficiency wages paid by each firm can decrease when competition becomes fiercer. With discretionary bonuses, instead, wages are generally uncorrelated with competition, but there exists an upper threshold for the number of competing firms, over which profits collapse to zero. Moreover, if information about firms' misbehaviour in paying bonuses flows in the labour market at a low rate, firms can make positive profits only by paying efficiency wages.

JEL Codes: J33, J41, L13

Keywords: industry profits, Cournot competition, efficiency wages, performance pay

*E-mail adresses: meccheri@ec.unipi.it (Meccheri) and lfanti@ec.unipi.it (Fanti)

1 Introduction

The nature of the relationship linking the number of firms competing in a product market and the industry profits (i.e. the sum of the firms' profits) is a fundamental determinant of market structure and functioning, since it strongly affects the incentives for firms in various directions (i.e. in decisions on colluding, merging, deterring entry by new firms, etc.). While in the standard Cournot model of oligopoly with exogenous production costs, as the number of firms in the market increases, industry profits decrease simply because firms' revenue diminishes owing to increased competition, the relationship between the number of competing firms and the industry profits was recently investigated by relaxing the assumption that production costs are exogenous (Naylor, 2002; Matsushima, 2006). In this regard, as is well-known from the literature on unionized oligopolies (see the seminal works by Horn and Wolinsky (1988) and Dowrick (1989)), labour markets play a significant role on the nature and outcome of product market competition due to the fact that labour represents for firms a major factor and cost of production. Moreover, contract theory (e.g. Hart and Holmström, 1987) has long stressed that, when workers' effort is not contractible, designing incentive contracts by firms becomes a crucial aspect for obtaining production goals and reducing labour costs.

The purpose of this paper is to investigate the interaction between incentive labour contracts, the number of firms competing *à la* Cournot in the product market and industry profits. With regard to labour incentive contracts, we refer to a framework in which workers' (agents') effort is (imperfectly) observable by firms (principals), but is not verifiable by a third party (e.g. a court). Hence, in order to provide parties with incentives to fulfil informal agreements, labour contracts must be designed so that the value of continuing the relationship in the future is sufficiently large that neither party wishes to renege on the contract (e.g. Bull, 1987; MacLeod and Malcomson, 1989). In particular, we consider two widely studied alternative incentive schemes, namely, efficiency wages and contracts with discretionary bonuses (e.g. Shapiro and Stiglitz, 1984; MacLeod and Malcomson, 1998; Malcomson, 1999), and compare their implications on industry profits when firms compete in the product market and use such schemes to motivate their workers.

In this context, we also introduce an important departure with respect to standard assumptions. In particular, we assume that the probability of an unemployed worker finding a job can depend on his/her past employment history. More exactly, workers who have been previously fired as the result of low effort may have a lower probability of finding a new job with respect to other workers. Furthermore, and more importantly, we relate such a possibility to the number of firms competing in the product market. As we will discuss, this can be motivated assuming that costs of gathering information about workers' previous employment histories increase with the number of firms in the market.

Our main results can be summarized as follows. When firms use efficiency wages and the number of firms competing in the product market is low, which implies that workers' reputation matters, the wage rent paid, in equilibrium, by each firm decreases if the probability of unemployed workers finding a job increases. This result, which is in contrast with the Shapiro and Stiglitz's (1984) shirking version of efficiency wages (where workers' reputation can never be established), is due to the fact that an increase in the probability of finding a job also increases the "opportunity-cost" of shirking and permits firms to elicit high effort from workers even with a lower wage. Moreover, since the "matching" probability for the unemployed increases with competition in the product market (i.e. with employment), if the number of competing firms is sufficiently low and the (positive) effect on the wage that derives from vanishing workers' reputation is not excessively strong, the efficiency wage paid by each single firm decreases as competition becomes fiercer. At the same time, however, industry's total wage bill (i.e. the sum of the firms' wages) always increases (hence, industry profits always decrease) because, with competition increasing at the margin, wage reduction for infra-marginal firms is always lower than the wage paid by marginal firm.

When firms adopt discretionary bonuses, instead, they do not need to provide any rent to their workers to motivate them. Thus workers' wages do not depend on unemployment in the labour market. As a consequence, wages are uncorrelated with the number of firms competing in the product market and industry profits decrease with number of firms only due to the standard competitive effect. However, this holds true only if the number of firms is no higher than a given threshold, which is related to product market as well as labour market parameters. Indeed, since profits decrease as the number of firms increases, there exists a critical threshold for the number of firms competing in the market, over which each single firm's profit is too low to make its promise to pay the bonus credible. Hence workers shirk on the job and profits collapse to zero.

The above results also open up the possibility of comparative analysis of the relation between the two incentive schemes considered and industry profits. Although efficiency wages imply firms pay a rent to motivate their workers while discretionary bonuses do not, there remains a possibility for industry profits to be higher when firms adopt efficiency wages. This could happen if profits with efficiency wages are still positive when the threshold related to the number of firms competing in the market is approached (that is, when profits collapse to zero when firms pay discretionary bonuses). In particular, in such a case, while profits are always higher with discretionary bonuses for relatively low numbers of competing firms, there exists a range, over and above the threshold, for which firms make higher (positive) profits by paying efficiency wages. We show that this applies when there is a relatively low rate at which information about firms' misbehaviour in paying bonuses flows in the labour market.

Our paper directly deals with the recent literature exploring the relation between the number of firms competing in the market and industry profits with endogenous production costs. In particular, the works of Naylor (2002) and Matsushima (2006) are those closest to ours. Naylor (2002) considers a bilateral oligopoly model, in which downstream firms' costs (wages) are determined through (Nash) bargaining with upstream agents (labour unions), and shows that the relationship between industry profits and the number of firms in the downstream sector depends on the relative bargaining power of the downstream and upstream agents.[1] Matsushima (2006), instead, shows that, under free entry into input markets, the relationship between industry profits and the number of firms competing in the (downstream) market depends on fixed costs (the ease of entry) in the input markets. Our paper differs in that, to the best of our knowledge, it is the first to study the connections between workers' motivation concerns and incentive contracts, and the number of firms in the (downstream) market and industry profits.

Due to the emphasis we place on incentives for workers, our paper could also be in some way related to the growing literature that investigates managerial delegation (see the seminal works of Fershtman (1985), Vickers (1985), Fershtman and Judd (1987) and Sklivas (1987)) and incentive contracts (see, in particular, Schmidt (1997) and Raith (2003)) in oligopolistic markets.[2] This literature, however, differs from our work mainly because it considers principal-agent problems, in which *formal* incentive contracts that link workers' (managers') pay to firms' performance measures (i.e. profit and revenue) are feasible, and studies changes in the optimal shape of incentive contracts following changes in product market competition. By contrast, we consider

[1]Similar works are: Horn and Wolinsky (1988), who study a differentiated oligopoly with upstream and downstream agents, but assume a duopolistic market; Dowrick (1989), who analyzes a bilateral oligopoly and shows that the bargained wage varies with the number of firms, but does not consider the relationship between profits and the number of firms; and Naylor (1999), who considers unionized oligopoly in the context of international trade, but does not allow the number of firms to vary.

[2]See Cuñat and Guadalupe (2005) for an empirical study on the effect of product market competition on the explicit compensation packages that firms offer their CEOs, executives and workers.

the effects of labour incentive contracts on industry profits (via changes in the number of firms competing in the product market) in a context in which formal incentive contracts are not feasible, or firms are reluctant to use verifiable signals of workers' performance (see below). Thus parties must rely on other contractual schemes, such as *termination* contracts or *informal (implicit)* incentive contracts.

Therefore, obviously, our work is based (and largely draws) on the implicit (self-enforcing) contracts literature. Most notably, in "anonymous" (labour) markets, that is, in a context where establishing an external reputation is impossible for both workers and firms, MacLeod and Malcomson (1998) model the choice between efficiency wages and performance pay with discretionary bonuses as a function of labour market conditions (i.e. presence of unemployed workers or unfilled vacancies). By contrast, the aim of this paper is to compare efficiency wages and performance pay in relation to product (instead of labour) market conditions and especially to study how they affect industry profits differently according to the number of firms competing in the product market. This requires that we consider a situation in which efficiency wages and discretionary bonuses are together sustainable in the labour market and this will lead to a framework, in which, on the one hand, there are unemployed workers and, on the other, some sort of firms' (and workers') reputation must play a role.[3]

The rest of the paper is organized as follows: in Section 2 the basic framework and unemployment values and flows are described. Section 3 presents the competition game in the product market and analyzes, as a benchmark case, a situation in which courts are faultless and omniscient agents. In this context, where effort-based labour contracts are fully enforceable, it will be possible to isolate the "competition effect" on industry profits, solely due to increasing the number of firms competing in the product market. Incentive labour schemes are studied in Section 4, while their effects on industry prof-

[3]The role of workers' reputation is discussed in Malcomson (1999), but it is not related to the degree of product market competition, as will be effected in this paper.

its operating via the number of firms competing in the product market are analyzed, compared and discussed in Section 5. Finally, Section 6 concludes, while technical proofs are relegated to the Appendix.

2 Model

2.1 Economic environment

Time is discrete, $t = 1, 2, ...$[4] There is a number $n \geq 1$ of identical firms competing *à la* Cournot repeatedly over time in a homogeneous goods market, with inverse demand function given by:

$$p = a - cQ \tag{1}$$

where $Q = \sum_{i=1}^{n} q_i$. There is also a pool of ℓ identical workers, with $\ell > n$. Each employment relationship consists of a repeated game played between a firm and a pool worker who form a match in a certain period and interact until their relationship is severed. Let us suppose that, at the end of each period, each match becomes unprofitable at the rate s for exogenous reasons and in such a case firm and employee separate. Firms and workers have infinite life, they are risk-neutral and discount the future with the same rate r. For simplicity, we concentrate on a situation in which each firm employs one single worker (e.g. the firm's top manager)[5] and all firms marginal costs, other

[4]Since in this environment the technology, the preferences and any other variable are stationary, that is, they remain unchanged over time, we do not need to denote variables by a time index.

[5]By concentrating upon the firm's top manager, we do not exclude the possibility that firms employ other workers to produce. However, we will only focalize on incentives for the manager and admit that providing proper incentives for the latter also ensures that all other workers inside firms adequately do their jobs. This is consistent with the "supervision hierarchies" or "scale-of-operations" literature (e.g. Calvo and Wellisz, 1978), according to which providing incentives for top executives in monitoring and control limits the scope for opportunistic behaviour by the subordinates, and, without loss of generality, permits to consider as constant the (marginal) cost of any other worker inside each firm.

than the wage of the considered worker, are constant and normalized at zero. The worker's effort (e.g. in decision, control and coordination functions) is essential for production and, in particular, we assume that the worker employed by firm i can choose an effort level $e_i \in \{e_i^l, e_i^h\}$, with $e_i^l < e_i^h$, such that:

$$q_i = \begin{cases} 0 & \text{if } \ e_i = e_i^l \\ \arg\max \pi_i & \text{if } \ e_i = e_i^h \end{cases} \tag{2}$$

where π_i is the firm i's per-period profit. That is, while high effort by the worker ensures producing the level of output that maximizes the firm's profit (which will be derived below in detail), there is no firm's production (hence, profits) when the worker "shirks" (i.e. he/she chooses $e_i = e_i^l$).[6] Furthermore, in each period, the worker employed by firm i obtains an utility given by:

$$u_i = w_i - e_i \tag{3}$$

where w_i is the wage paid by firm i, while we normalize to zero the utility of the worker when unemployed.

According to the self-enforcing contracts literature (e.g. MacLeod and Malcomson, 1989, 1998), and in contrast with the standard principal-agent models (e.g. Hart and Holmström, 1987), we assume that workers' effort is *observable*, even if imperfectly. That is, in each period, firms always have a strictly positive probability to observe the level of effort chosen by their workers. However, effort is not *verifiable* by a court and other verifiable measures of performance are not available or it is not in firms' interests to use them to motivate workers (e.g. Holmström and Milgrom, 1991; Baker, 1992). This is in accordance with Williamson et al. (1975), who emphasize that workers' performance (or effort) is frequently something that a court is unable to measure.[7]

[6]The hypothesis of zero firm i's output (and profits) with $e_i = e_i^l$, whilst useful to simplify the following analysis, is not essential, from a qualitative viewpoint, for final results.

[7]In many situations, implicit contracts (also labelled as "relational contracts"), may

2.2 Unemployment values and flows

In relation to labour market functioning, it is important to define first the general aspects connected with unemployment values and flows, since we introduce an important departure with respect to standard assumptions. We admit that the probability of an unemployed worker finding a job in any period can depend on his/her past employment history. In particular, workers who have been previously fired by a firm as the result of low effort *can be* characterized by a different (i.e. lower) probability of finding a new job compared with other workers. This is in contrast with the standard shirking version of efficiency wage models, stemming from Shapiro and Stiglitz (1984), according to which a bad reputation for shirking workers cannot be established in the labour market. Hence unemployed values for "shirkers" and "non-shirkers" are always the same. As emphasized by Malcomson (1999, p. 2340), the Shapiro-Stiglitz's "anonymous" labour market assumption is plausible when acquiring information about workers' previous employment experience is costly for firms. In this paper, we hypothesize that this cost is related to the number of firms operating in the market, that is, the larger the number of firms, the higher the cost that firms must bear to acquire information about workers. We believe this is consistent with MacLeod and Malcomson's (1998, pp. 392-3) argument that "in an anonymous market [...] it is hard to keep track of participants, something that may well be true of workers from poor areas of large cities"; "large markets" (i.e. markets with a relatively high number of competing firms), similarly to large cities, make keeping track of workers more difficult and costly for firms. In particular, we assume that if the product market is extremely competitive, the cost to discover workers' previous employment experience is too high and the Shapiro-Stiglitz assumption holds. By contrast, if a small number of firms compete in the market, acquiring information is relatively cheap and workers'

outperform formal agreements. For instance, an informal contract may allow parties to utilize their detailed knowledge and adapt to new contingencies as soon as they become known, even when such information is not promptly verifiable by a court.

reputation becomes important.[8]

Using U^l and U^h to indicate the expected discounted lifetime utility of an unemployed worker who has and has not been previously fired for shirking, respectively, starting from a generic period of time t, we have:[9]

$$U^k = \frac{JmE^k}{1+r} + \frac{(1-Jm)U^k}{1+r} \Longrightarrow U^k = \frac{JmE^k}{r+Jm} \tag{4}$$

where $k \in \{l, h\}$, E^k indicates the expected discounted lifetime utility, from a generic period of time, of an employed worker of type k, m is the (matching) probability to find a job, in any period, for an unemployed worker who never shirked before and, finally, J is an index function, such that $J = 1$ if $k = h$ and $J = \theta$ if $k = l$.

Hence, the term θ represents the possibility for firms to acquire information about workers' previous experience (or, alternatively, the possibility for workers to establish a reputation in the labour market) and, as discussed above, we assume that it depends on the number of firms in the market.

Assumption 1 *The function $\theta = \theta(n) \in [0, 1)$, with $\theta(1) = 0$ and $1-\theta(n) < \varepsilon$ (with ε a small positive infinitesimal quantity) for any $n \geq \overline{n}$, with $\overline{n}$ sufficiently large. Furthermore, for any n, $\theta(n)$ is continuously differentiable and non-decreasing.*

According to Assumption 1, when the number of firms is sufficiently large ($n \geq \overline{n}$), hence the product market is (sufficiently) competitive, $\theta \approx 1$ and the Shapiro-Stiglitz "anonymous" market hypothesis holds. Hence, the matching probability of finding a new job is the same and equal (or approximately

[8]Consider, for instance, the extreme case of a monopolistic market. Since a worker who has been fired for shirking could find another job (in the same labour market) only with the same firm, the cost the latter must bear to acquire information about the worker's previous experience is negligible. Moreover, also in the case of a duopoly, such a cost may be relatively low: at most, each firm should "investigate" the worker's previous experience, if any, with the only other firm in the market.

[9]From here onwards, in order to streamline the notation, we omit the index i whenever it is unnecessary.

equal) to m for all workers. Instead, when the product market is a monopoly, acquiring information about workers' previous employment histories in the labour market of interest is negligible. Thus a worker once fired for shirking is never employed again. Obviously, for intermediate n's values, workers' reputation can be established to some extent (depending on n). Hence workers previously fired for shirking could get new jobs with lower (but positive) probability than other workers (i.e. $0 < \theta m < m$).

In a stationary equilibrium, all employed workers do not shirk (i.e. $e_i = e_i^h, \forall i$) and lose their jobs only for exogenous reasons. Furthermore, movements into and out of unemployment must balance. In each period, workers seeking a job consist of $\ell - n$, who were unemployed in the previous period, plus sn who have just lost their jobs for exogenous reasons, while sn jobs are created to replace those that have been lost. Hence, the matching probability for an unemployed worker is given by:

$$m = \frac{sn}{\ell - (1-s)n}. \tag{5}$$

Instead, since ℓ is sufficiently large to satisfy whatever labour demand, and no search or matching frictions are assumed in this economic environment, in a stationary equilibrium, where all firms' implicit promises or contracts are honoured, each firm promptly finds a new worker when an employment relationship is severed for exogenous reasons.[10] Also note that in this context, it is natural to assume that firms have all market power *vis-à-vis* their workers and can fix the lowest pay *compatible* with the workers' high effort.

In what follows, we study a non-cooperative two-stage game. In the first stage, since workers' effort is not verifiable by courts, firms and workers must design a labour contract ensuring that the latter do not shirk. In the second stage, conceding that labour contracts have been designed adequately in the first stage, firms compete *á la* Cournot in the product market setting their

[10] Assumptions about firms' reputation are described in greater detail in Section 4.2.

outputs to maximize profits. We proceed by backward induction.

3 Stage two: the product market game

According to the economic environment described above, per-period profit for the representative firm i can be written as:

$$\pi_i = pq_i - w_i = [a - c(q_i + Q_{-i})]q_i - w_i \tag{6}$$

where $Q_{-i} = q_j$ is the sum of the quantities supplied by the other firms.[11]

Under the Cournot-Nash assumption, differentiation of Eq. (6) with respect to q_i yields the first-order condition for profit maximization by firm i, from which we can derive the firm i's reaction function in the output space as:

$$q_i = \frac{a - cQ_{-i}}{2c}. \tag{7}$$

Solving all firms' reaction functions simultaneously allows us to derive the stage-two symmetric equilibrium firm i's output (with $q_i = q, \forall i$), as:

$$q = \frac{a}{(n+1)c}. \tag{8}$$

By substituting Eq. (8) into Eq. (6), we get an expression for the firm i's profit that, in symmetric equilibrium ($\pi_i = \pi, \forall i$), is given by:

$$\pi = \frac{a^2}{(n+1)^2 c} - w \tag{9}$$

where w $(= w_i, \forall i)$ is the outcome of the stage-one game determining the optimal incentive labour contract. Finally, also note that, since no fixed costs are included in this economic environment, it will make sense to focus only on situations in which firms' (hence, industry's) profits are positive.

[11] Clearly, in the monopoly special case $Q_{-i} = 0$.

3.1 "Fully verifiable" effort and competition effect

Before analyzing the nature and the effects of incentive contracts with unverifiable effort, let us briefly consider, as a benchmark case, an environment where effort is verifiable (and perfectly observable), courts are omniscient agents and every contract is enforced. In such a situation, a firm which aims to elicit its worker's effort can design a labour contract in each period that simply makes the whole payment of its worker contingent upon the provision of e^h. Clearly, the worker will provide e^h as long as the wage compensates him/her for the reservation (unemployment) utility plus the disutility for "high" effort, that is, recalling that unemployment utility is normalized to zero, as long as $w \geq e^h$. Hence, a profit-maximizing firm (with all market power) will set $w = e^h$ and, according to Eq. (9), in equilibrium, each single firm and industry (per-period) profits (π_{FV} and $(\sum \pi)_{FV}$, respectively) will be given by:

$$\pi_{FV} = \frac{a^2}{(n+1)^2 c} - e^h \tag{10}$$

$$\left(\sum \pi\right)_{FV} = n\pi_{FV} = \frac{na^2}{(n+1)^2 c} - ne^h. \tag{11}$$

From Eq. (11), it may be shown that increasing n, the number of firms competing in the market, reduces industry profits:

$$\frac{\partial (\sum \pi)_{FV}}{\partial n} = \pi_{FV} + n\frac{\partial \pi_{FV}}{\partial n} = \frac{(1-n)a^2}{(n+1)^3 c} - e^h < 0 \tag{12}$$

with $n \geq 1$. This result can be related to the standard effect of increased competition in the product market (e.g. Naylor, 2002).

4 Stage one: the labour incentive contract

Obviously, when effort is not verifiable, parties must be able to design alternative arrangements to incentivise devices based on perfectly enforceable variables. Shirking versions of efficiency wage models (also known as "termination contracts") attain such result with contracts in which the wage is independent of performance and workers are discouraged from shirking by the threat that the contract will be terminated and fewer alternative employment opportunities will be available in the future. Instead, when firms promise to pay a discretionary bonus, the situation is more problematic since, in principle, they always have the incentive to renege on the promise if there is no future consequence for this. In what follows, we briefly analyze the functioning of these incentive mechanisms and outline the most important results thereof that apply in our framework. Instead, the incentive schemes' effects on industry profits, via interaction with the number of firms competing in the product market, will be studied in Section 5 in greater detail.

4.1 Efficiency wages

As already stated, the best known model in shirking versions of efficiency wages is that of Shapiro and Stiglitz (1984). Here we consider a version of the same model modified to take into account the assumption, described above, about workers' matching probability.[12] Let us assume that firms monitor their workers in each period with probability x and define with E^l_{EW} the expected discounted lifetime utility for a worker choosing e^l. Assuming, for simplicity, that per-period payoffs are made at the end of the period and the worker who is caught shirking (with probability x) is fired, E^l_{EW} is given by:[13]

$$E^l_{EW} = \frac{\widehat{w} - e^l}{1+r} + \frac{(s+x)U^l}{1+r} + \frac{(1-s-x)E^l_{EW}}{1+r} \Longrightarrow E^l_{EW} = \frac{\widehat{w} - e^l + (s+x)U^l}{r+s+x} \tag{13}$$

[12]We also work with discrete time while Shapiro and Stiglitz's (1984) model is set in continuous time.

[13]Moreover, we make the standard assumption (e.g. Blanchard and Fisher, 1989, Ch. 9) that the period is short enough that we can ignore terms that are products of s and x.

where $\widehat{w}$ denotes the (efficiency) wage paid by the firm. Instead, the expected discounted lifetime utility for a worker choosing e^h, E^h_{EW}, is:

$$E^h_{EW} = \frac{\widehat{w} - e^h}{1+r} + \frac{sU^h}{1+r} + \frac{(1-s)E^h_{EW}}{1+r} \Longrightarrow E^h_{EW} = \frac{\widehat{w} - e^h + sU^h}{r+s}. \quad (14)$$

Hence, the worker will certainly shirk unless $E^h_{EW} \geq E^l_{EW}$. Substituting for U^l and U^h from Eq. (4) in Eqs. (13) and (14), respectively, rearranging and solving for $\widehat{w}$, we get the following incentive-compatibility condition (or "no-shirking condition") for the worker:

$$\widehat{w} \geq e^h + \left(e^h - e^l\right)\left[\frac{(r+\theta m)(r+s+m)}{(r+m)x}\right] \quad (15)$$

which, in equilibrium, holds with equality because profit-maximizing firms pay the lowest wages consistent with it.[14]

Define with α the last term in brackets of the Eq. (15)'s r.h.s. As usual, since $\alpha > 0$, firms must pay a rent to their workers in order to motivate them. Also note that, as is intuitive, α positively depends on θ: when workers' reputation matters (lower θ's values), firms are able to get high effort by workers even by paying them lower wage rents. Furthermore, for $n \geq \overline{n}$ ($\theta \approx 1$), $\alpha \approx \frac{r+s+m}{x}$ and the Shapiro-Stiglitz standard results apply (i.e. the efficiency wage increases with r, s and m and decreases with x). By contrast, when n (hence, θ) is sufficiently low, a different result can be obtained in relation to m.

Result 1 *For a sufficiently low n (number of firms competing in the product market) the efficiency wage decreases when the matching probability m increases.*

[14]To be exact, the denominator of the term in squared brackets is $(r+m)x + sm(1-\theta)$. In order to simplify the following analysis, without substantially affecting the final results, we have omitted the second addendum because it is negligible. In particular, (while s is always sufficiently low; see fn 13) when m is sufficiently high (because n is large), $1-\theta$ is close to zero and *vice versa*.

Proof. See the Appendix. ■

The rationale behind the Result 1 is straightforward. If workers' reputation does not play any role, there is no difference for workers between losing a job due to shirking or for exogenous reasons. Thus, as highlighted by Shapiro and Stiglitz (1984), an increase in m makes losing a job less severe for *all* workers, and forces firms to pay higher wages to motivate them. By contrast, when workers' reputation matters (i.e. n and θ are sufficiently low), an increase in m increases the "opportunity-cost" of shirking (because losing a job due to shirking means that the probability of being re-employed becomes zero, or greatly decreases, for shirkers). This permits firms to elicit high effort from workers, even with a lower wage.[15]

4.2 Discretionary bonuses

Let the worker's wage w now be divided into two components: a fixed salary $\underline{w}$ (whose payment can be enforced by a court) plus a bonus element b (e.g. Bull, 1987; MacLeod and Malcomson, 1989). Since effort is not fully observable, the best a firm can do is not to pay the bonus only to workers that are caught shirking (before firing them). Moreover, being an implicit agreement, the bonus payment cannot be enforced by a court (e.g. a firm can always argue that the worker was previously promised no bonus or that it has been paid, even if this did not actually happen). Hence, since paying the bonus is costly for the firm, the latter could always be tempted not to pay it even if the worker chooses e^h. This produces a classic Prisoners' Dilemma distortion in this context: in a single period game, since the firm cannot commit to paying

[15]From Eq. (15), it is trivial to check that the Shapiro-Stiglitz results, as regards r and x, hold for any n (i.e. any $\theta \in [0, 1)$). The same applies for s, even if, when workers' reputation matters, its role becomes more complex. This is because an increase in s, in turn, produces an increase in m (see Eq. (5)), which actually reduces the efficiency wage. It may be shown, however, that, in a stationary equilibrium, the latter effect never outweighs the "traditional" one. Hence the efficiency wage always (i.e. for any n) increases with s (formal proof is available from the authors upon request).

the bonus, the worker will perform no more than e^l, and the firm will not produce at all. But, when the game is repeated infinitely (or indefinitely) a sort of "Folk Theorem" could apply. This, however, requires that the contract between parties be self-enforcing, i.e. it must always give both parties the incentive to fulfil their respective parts of the agreement, despite the fact that it is not enforceable by a court.

Once again, we will proceed in two steps. First, allowing that the firm honors its promises, we find the bonus value to obtain e^h. Secondly, given the optimal bonus, we define conditions that make the firm's promise to pay the bonus part of a self-enforcing contract. This latter step will lead us to clarify the crucial role played, in this direction, by the number of firms competing in the product market.

The incentive-compatibility constraint for the worker According to the previous argument, when firms adopt discretionary bonuses to motivate their workers, we can represent the expected discounted lifetime utility of a worker choosing e^l, E_B^l, as:

$$E_B^l = \frac{\underline{w} + (1-x)b - e^l}{1+r} + \frac{(s+x)U^l}{1+r} + \frac{(1-s-x)E_B^l}{1+r} \Longrightarrow$$

$$\Longrightarrow E_B^l = \frac{\underline{w} + (1-x)b - e^l + (s+x)U^l}{r+s+x}. \qquad (16)$$

Instead, if the worker chooses e^h his/her expected discounted lifetime utility E_B^h is:

$$E_B^h = \frac{\underline{w} + b - e^h}{1+r} + \frac{sU^h}{1+r} + \frac{(1-s)E_B^h}{1+r} \Longrightarrow E_B^h = \frac{\underline{w} + b - e^h + sU^h}{r+s}. \qquad (17)$$

Clearly, workers will shirk unless $E_B^h \geq E_B^l$. Admitting that firms exploit their market power to fix the salary component such that workers exactly receive their opportunity cost (i.e. $\underline{w} = e^h - b$), and solving for the bonus (the implicit part of the incentive contract), we get the following incentive-compatibility condition for the worker:

$$b \geq \frac{e^h - e^l}{x}. \quad (18)$$

Firms choose the lowest bonus compatible with Eq. (18), which, in equilibrium, holds with equality. As is well known (e.g. Malcomson, 1999), unlike the efficiency wages case, firms can potentially motivate workers without providing them with a rent. On this point, also note that θ (i.e. the possibility for workers to establish a good reputation in the labour market), hence differences in unemployment values of shirkers and non-shirkers, do not play any role in providing incentives for high effort. This is because, in the equilibrium with bonuses, employed workers receive exactly the same utility as unemployed ones.

The incentive-compatibility constraint for the firm Firms, however, must be able to credibly commit themselves to paying b in order to obtain e^h from their workers. This is not possible in a one-shot game, but standard repeated game logic can imply that firms will compensate workers in the appropriate way. Formally, together with the incentive-compatibility condition for the worker, an incentive-compatibility condition for the firm must also be satisfied in equilibrium.

As pointed out in the literature (e.g. Carmichael, 1984), in ongoing relationships, when agents learn past employment histories of partners, reputation can play a central role in ensuring that firms honor their promises, since losing one's employee as the result of cheating on a promised bonus could produce worse future opportunities than when parties separate for other (exogenous) reasons. Labour unions, for instance, may contribute in this direction by monitoring the employment relationships between a firm and its workers and providing the workforce with valuable information regarding the firm's adherence to implicit contracts, as formally studied in Hogan (2001). Furthermore, also firms themselves could have an interest in credibly fostering the transmission of such information to the market since, by committing themselves more strongly, they can offer a broader range of incentives (e.g.

Kreps and Wilson, 1982; Tirole, 1996; Tadelis, 1999; Levin, 2002).[16]

Even if there are reasons supporting the hypothesis that, in general, information on past employment behaviour flows in the labour market more widely in relation to firms than workers, it is implausible, as emphasized by Malcomson (1999), that each time a firm loses employees because of cheating on promised bonuses it is never able to recruit a new worker, just as an employee once fired for shirking is never re-employed. Thus, in order to make our analysis more general, we consider a situation in which information on firms' misbehaviour does not always flow in the labour market, but it does so only with a positive per-period probability z.[17] Nevertheless, each time this occurs, cheating behaviour by a firm is interpreted by the labour workforce as a whole as evidence that firm does not fulfil informal agreements with its workers. This means that no worker will be motivated to work hard for that firm in the future.[18]

Indicating with Π^{nc} the expected discounted profit for a "non-cheating" firm, i.e. a firm that honestly pays the bonus to its worker who expends e^h, this is given by:

[16] There are mechanisms other than a firm's reputation that, upon creating a rent for the firm in continuing employment relationship, prevent the temptation to cheat on the promised bonus. For instance, as already mentioned in the Introduction, with a rationale mirroring that used by Shapiro and Stiglitz (1984), MacLeod and Malcomson (1998) show that, when there is excess demand for labour and unfilled vacancies, firms are better off keeping rather than losing their current employees due to cheating on the bonus since they may not find another straightaway. Furthermore, if there are turnover or firing costs, specific investments or matching frictions, as in Ramey and Watson (1997) and Scoppa (2003), and if those are sufficiently large, they may by themselves be enough to ensure the firm's honest behaviour.

[17] It could be argued that, since we have related θ (which reflects how workers' reputation flows in the market) to the number of competing firms, this could also be done for z. The latter argument, however, seems more problematic. For instance, in the monopoly case, it could be difficult (as well as in a more competitive case) for external agents to verify whether the firm has promised to pay a bonus or if the latter was actually paid.

[18] See Doering and Piore (1971) and Bewley (1999) for some evidence, which supports such a hypothesis.

$$\Pi^{nc} = \frac{\pi}{1+r} + \frac{\Pi^{nc}}{1+r} \Longrightarrow \Pi^{nc} = \frac{\pi}{r}. \tag{19}$$

Instead, since the firm's profit is negative with low effort by its worker, it is always better for the firm to end an employment relationship than let it continue with low effort in the future. Thus, the expected discounted profit for a "cheating" firm, Π^c, is:

$$\Pi^c = \frac{\pi + b}{1+r} + \frac{(1-z)\Pi^c}{1+r} \Longrightarrow \Pi^c = \frac{\pi + b}{r+z}. \tag{20}$$

A cheating firm saves on the bonus in the current period (and fires its worker at the end of the period). However, if information about its cheating behaviour flows in the labour market (which occurs with probability z), it loses its reputation and no worker will be willing to expend e^h for that firm onwards. Hence, the firm cheats on the bonus payment unless $\Pi^{nc} \geq \Pi^c$. Solving for π, we obtain the following incentive-compatibility, or "no-cheating", condition for the firm:

$$\pi \geq \left(\frac{r}{z}\right) b. \tag{21}$$

In order to define the aggregate condition that makes implicit agreements self-enforceable, we add the worker's incentive-compatibility condition, Eq. (18), to the firm's no-cheating condition, Eq. (21) and, taking into account that the firm makes the lowest (incentive-compatible) payments, we get:[19]

$$\pi \geq \left(\frac{r}{z}\right) \left(\frac{e^h - e^l}{x}\right) \tag{22}$$

which, by substituting for Eq. (9), i.e. the equilibrium value for the firm's profit in stage 2 (the product market game), can be rewritten as:

$$\frac{a^2}{(n+1)^2 c} - e^h \geq \left(\frac{r}{z}\right) \left(\frac{e^h - e^l}{x}\right). \tag{23}$$

[19] It follows directly from its derivation that the following equation is a necessary and sufficient condition for cooperative payoffs to be supported as subgame perfect equilibria (e.g. MacLeod and Malcomson, 1989).

Solving Eq. (23) for n and using some algebra, we obtain the following condition for the number of firms competing in the product market, which must be satisfied in a self-enforcing equilibrium:

$$n \leq \tilde{n} \equiv \frac{a}{\sqrt{c\left[e^h + \left(\frac{r}{z}\right)\left(\frac{e^h - e^l}{x}\right)\right]}} - 1. \tag{24}$$

Since firms' profits are decreasing in n, Eq. (24) establishes an upper constraint for the number of firms competing in the product market, for which implicit contracts are sustainable as a self-enforcing equilibrium. In particular, such an upper constraint is related to both product market and labour market parameters. In detail, the higher a and the lower c (i.e. the higher the scale or size of the product market), the higher the upper constraint $\tilde{n}$. Moreover, the lower the (extra) cost of high effort e^h (or $e^h - e^l$) and the higher the monitoring efficiency, x, and the frequency with which information on firms' misbehaviour flows in the labour market, z, the higher the upper constraint $\tilde{n}$.[20] Finally, for the usual reasons, it also negatively depends on the discount rate r. The following statement summarizes such findings.

Result 2 *There exists an upper threshold for the number of firms competing in the product market, over which firms' (hence, industry's) profits collapse to zero when they use discretionary bonuses to motivate their workers. This threshold is positively related to a, x and z and negatively related to c, e^h (or $e^h - e^l$) and r.*

[20] In particular, note that if $z \to 0$ (i.e. a firm's reputational mechanism does not work at all), the firm would never gain by sticking to the agreement even if the relationships were repeated over time. Hence there is no (positive) number of firms for which implicit self-enforcing contracts can be established. The same holds true if $x \to 0$ because, in such a case, the bonus component would be excessively large for Eq. (22) to be satisfied.

5 Product market competition, wages and industry profits

Using the results of the previous sections, we can now explore how competition in the product market affects industry profits according to the incentive scheme firms use to motivate their workers.

By substituting the efficiency wage (Eq. (15) with equality) in the firm's profit equation (Eq. (9)), we get:

$$\pi_{EW} = \frac{a^2}{(n+1)^2 c} - e^h + \left(e^h - e^l\right)\alpha. \tag{25}$$

Instead, with self-enforcing discretionary bonuses, wages do not depend on the number of firms competing in the product market and are exactly equal to the case with perfectly contractible effort. Furthermore, firm's profit is given by:

$$\pi_B = \begin{cases} \frac{a^2}{(n+1)^2 c} - e^h & \text{if } \ n \leq \tilde{n} \\ 0 & \text{if } \ n > \tilde{n}. \end{cases} \tag{26}$$

From Eqs. (25) and (26), we can easily derive corresponding industry profits with the two alternative incentive schemes as, respectively:

$$\left(\sum \pi\right)_{EW} = n\pi_{EW} = \frac{na^2}{(n+1)^2 c} - n\left[e^h + \left(e^h - e^l\right)\alpha\right] \tag{27}$$

$$\left(\sum \pi\right)_{B} = n\pi_{B} = \begin{cases} \frac{na^2}{(n+1)^2 c} - ne^h & \text{if } \ n \leq \tilde{n} \\ 0 & \text{if } \ n > \tilde{n}. \end{cases} \tag{28}$$

Before comparing industry profits with alternative incentive schemes, it is worth emphasizing an aspect in relation to competition and wage behaviour. Indeed, whilst our previous analysis already indicated that, with discretionary bonuses, the wage paid by each firm does not depend on product market competition and it is simple to verify that firms' (and industry's) wages are always greater (and always increase more rapidly) when firms elicit workers' effort by paying efficiency wages instead of discretionary bonuses, the following statement highlights an interesting, and less obvious, finding.

Result 3 *When competition increases, the efficiency wage paid by each single firm decreases if (and only if):*

- *n is sufficiently low, and;*
- *the (positive) effect of vanishing workers' reputation (i.e. increasing θ) on the wage is relatively low.*

However, the industry total wage bill (i.e. the sum of the firms' wages) always increases with n.

Proof. See the Appendix. ■

Result 3 can be explained as follows. An increase in competition increases employment, thus leading to an increase in the matching probability m. In turn, the latter produces two effects on the efficiency wage, which operate against one another. The first is the typical Shapiro-Stiglitz effect that increases the wage, while the second, which is related to the role of workers' reputation in the labour market, was described above by Result 1 and operates in the opposite direction. The relative importance of the effects depends on θ. We previously showed that, if θ (i.e. n) is sufficiently low, the latter outweighs the former. However, besides increasing m, an increase in n also produces another important effect, namely it increases θ. This reduces the role played by workers' reputation in the labour market and increases the rent firms must pay to motivate their workers. Furthermore, even if the "negative" m's effect outweighs the "positive" m's and θ's effects combined, only wages paid by infra-marginal firms decrease, while the industry total wage bill increases. This is because the total wage reduction for infra-marginal firms is always lower than the wage paid by marginal firm.[21]

[21] The issue of wage behaviour according to changes in the number of firms competing in the (oligopolistic) product market is also studied in Dowrick (1989). In particular, Dowrick

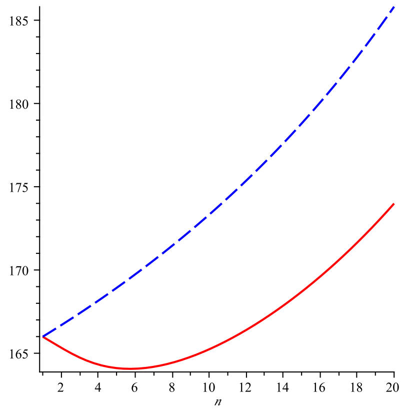

Figure 1: Firm's wage with EW

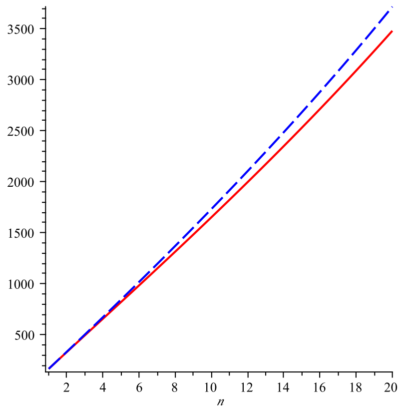

Figure 2: Industry's wages with EW

Figures 1 and 2 show, for the specific functional form $\theta = \frac{(n-1)^{\gamma}}{n^{\gamma}+\beta}$, which is consistent with Assumption 1, and selected parameter values, different possible firm's (and corresponding industry's total) wage behaviour as a function of n, under an "optimal efficiency wage contract".[22]

Obviously, since both with efficiency wages and discretionary bonuses industry's total wage bill increases (and total revenues decrease) with n, industry profits always decrease when competition increases. Formally, by differentiating Eqs. (27) and (28), respectively, with respect to n (and recalling from the proof of Result 3 that $\alpha - n\frac{\partial \alpha}{\partial n} > 0$; see the Appendix A.2), it is easy to show that:

(1989, Proposition 2) shows that the effect of an increase in competition on (firms') wages is ambiguous but, generally, wages decrease as the number of competing firms increases. However, in Dowrick (1989) the effects of competition on wages operate by affecting rents over which unions bargain, while, in our framework, they relate to changes produced in the optimal incentive (efficiency) wage contract.

[22]Parameter values used for Figures 1 and 2 are: $e^h = 100; e^l = 0; s = r = 0.1; x = 0.3; \ell = 50; \gamma = 10$ and $\beta = 1000$, for red solid lines; $\gamma = 1$ and $\beta = 0$, for blue dashed lines. Note that for $\gamma = 1$ and $\beta = 0$ the firm's wage initially decreases in n since, in such a case (unlike that with $\gamma = 10$ and $\beta = 1000$), workers' reputation vanishes very slowly as n increases, i.e. for low n values, $\theta'(n)$ is very small (see also Eq. (38) of Appendix A.2).

$$\frac{\partial\left(\sum\pi\right)_{EW}}{\partial n}=\frac{(1-n)a^2}{(n+1)^3c}-e^h-(e_h-e_l)(\alpha-n\frac{\partial\alpha}{\partial n})<0 \tag{29}$$

$$\frac{\partial\left(\sum\pi\right)_{B}}{\partial n}\mid_{n\leq\tilde{n}}=\frac{(1-n)a^2}{(n+1)^3c}-e^h=\frac{\partial\left(\sum\pi\right)_{FV}}{\partial n}<0 \tag{30}$$

and

$$\left|\frac{\partial\left(\sum\pi\right)_{EW}}{\partial n}\right|>\left|\frac{\partial\left(\sum\pi\right)_{B}}{\partial n}\mid_{n\leq\tilde{n}}\right|. \tag{31}$$

Hence, as n increases, industry profits decrease more rapidly with efficiency wages than with discretionary bonuses.[23]

According to such results, one could also be tempted to deduce that industry profits can never be greater with efficiency wages than with discretionary bonuses. Nevertheless, a further step is needed. As shown above, this is because (industry) profits with discretionary bonuses collapse to zero when the number of competing firms exceeds a critical threshold. Hence, for relatively large numbers of firms (i.e. for $n>\tilde{n}$), there could be the possibility that firms make greater (positive) profits with efficiency wages.

Figure 3 clarifies this point in more detail: it describes industry profits behaviour, in relation to the number of firms competing in the market, with alternative incentive schemes (blue dashed lines for efficiency wages and red solid lines for discretionary bonuses) and for two alternative cases, both hypothetically plausible. In Case 1, industry profits with efficiency wages are already negative when n approaches $\tilde{n}$, hence there is no possibility for them to be higher than with discretionary bonuses. By contrast, in Case 2, profits with efficiency wages are still positive when n reaches $\tilde{n}$, hence there exists a range, over and above the threshold $\tilde{n}$, for which firms make higher (positive) profits by paying efficiency wages.

[23] In particular, like the case with fully verifiable effort, with discretionary bonuses no rent is needed to motivate workers and profits decrease only due to the standard competition effect.

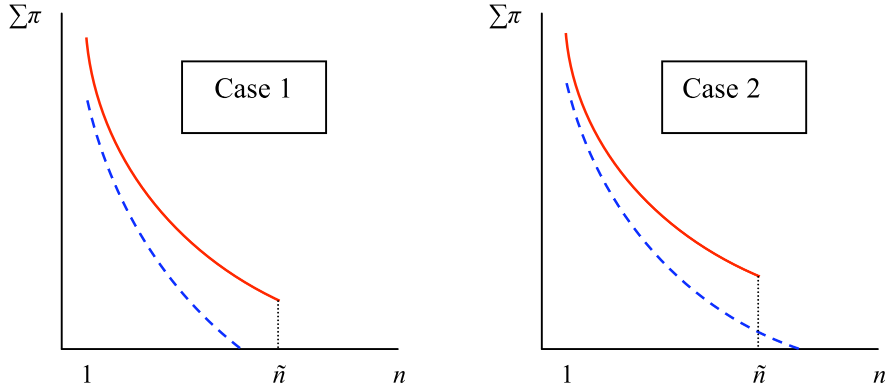

Figure 3: Incentive schemes, competition and industry profits

Result 4 *If the rate z, with which firms' reputation flows in the labour market, is lower than a critical threshold negatively related to the value of α for $n = \tilde{n}$, there exists a range over and above $\tilde{n}$, for which industry profits are higher with efficiency wages (i.e. Case 2 in Figure 3 applies). Otherwise, there is no n for which industry profits are greater with efficiency wages than with discretionary bonuses (i.e. Case 1 in Figure 3 applies).*

Proof. See the Appendix. ■

Industry profits can be higher with efficiency wages only if they are positive when $n = \tilde{n}$. Taking into account that $(\sum \pi)_{EW}$ is (rapidly) decreasing in n, this can happen only if $\tilde{n}$ is sufficiently low, which occurs also if z is (relatively) low. Moreover, when firms pay efficiency wages, industry profits decrease with α (the term related to the wage rent). Hence, z should be relatively low with respect to a given threshold, negatively related to α computed for $n = \tilde{n}$, for industry profits to be higher (or, in other words, to be positive when $n = \tilde{n}$) when firms elicit workers' effort by paying efficiency wages instead of discretionary bonuses.[24]

[24]In this regard, note that the effect of some parameters (e.g. x or r) is not clear-cut, since they generate both direct and indirect effects that can act against one another. In particular, on the one hand, they can reduce (increase) $\tilde{n}$, while, on the other, they can increase (decrease) α, hence reducing (increasing), for any n, industry profits with

Before concluding, also note that when Case 1 in Figure 3 applies, that is, industry profits are never higher with efficiency wages, the critical threshold with discretionary bonuses, $\tilde{n}$, represents the largest number of firms for which industry profits can be positive. As already remarked, this threshold is related to product market (as well as labour market) parameters. In particular, the larger the size of the market, the larger the critical number of firms for which profits can be positive. Although this statement is hardly breaking new ground, it is important to stress that with respect to the standard rationale, according to which the number of firms operating (efficiently) in a market is directly related to its size simply due to the presence of "demand constraints", we derived this result in quite a new fashion (which, in some sense, reinforces the standard rationale): when markets are thin (with low a/c), larger numbers of competing firms make implicit labour incentive contracts unsustainable as self-enforcing equilibria.

Instead, when Case 2 in Figure 3 applies, the threshold $\tilde{n}$ represents a critical degree of product market competition, above which firms find it worth modifying the incentive scheme adopted to motivate their workers. More exactly, when $n = \tilde{n}$ (and incumbent firms are making higher profits by using discretionary bonuses), a new firm can earn a positive profit by entering into the market, but only if it uses efficiency wages to elicit its worker's effort. Furthermore, the entry of the new firm also forces those already present in the market to change their incentive scheme, since discretionary bonuses become no longer sustainable as a self-enforcing equilibrium. Hence, when $n = \tilde{n}$ and a new firm enters the market, the profits of incumbent firms decrease for two different reasons: first, as usual, because increasing competition reduces their revenues; secondly, because it also increases their wages, due to the fact that it forces them to switch from a less costly to a more costly (incentive)

efficiency wages. Moreover, by contributing to define $\tilde{n}$, they also indirectly affect the corresponding (equilibrium) efficiency wage via the workers' matching probability (which, as discussed above, plays an ambiguous role on the wage).

wage contract (i.e. from bonuses to efficiency wages).[25]

6 Conclusion

In this paper, the interaction between product market competition and industry profits was analyzed in a framework where workers' effort is (imperfectly) observable by firms, but is not verifiable by a third party (e.g. a court). Moreover, it was assumed that the probability of unemployed workers getting a job may depend on their employment histories and, more importantly, that such a possibility relates to the degree of market competition, because the costs of gathering information about workers' employment histories increase with the number of firms in the market. In this context, the effects of two well-known incentive schemes, namely, efficiency wages and contracts with discretionary bonuses, were studied and compared.

Efficiency wages paid by each firm can decrease when competition (hence, employment) increases. At the same time, however, the industry total wage bill (i.e. the sum of firms' wages) always increases (hence, industry profits always decrease) because, on increasing competition at the margin, the total wage reduction for infra-marginal firms is always lower than the wage paid by the marginal one. When firms adopt discretionary bonuses, instead, wages are uncorrelated with the number of firms in the product market, but there exists an upper threshold for the number of competing firms, over which profits go to zero. This is because each single firm's profit is too low to make its promise to pay the bonus credible. Moreover, although efficiency wages

[25] Notice that this finding opens up to non-trivial social welfare issues in relation to market entry by new firms which, however, fall outside the scope of this paper and are left for future research. Furthermore, it can also provide some important indications for testable hypotheses by empirical research on incentive contracts. For instance, it seems to suggest that, *ceteris paribus*, we would observe discretionary bonuses in industries with relatively low numbers of firms, while efficiency wages should emerge, in a time series view, when (in the same industries) competition becomes fiercer or, in a cross section view, in other industries characterized (at the same time) by a higher degree of competition.

imply firms pay a rent to motivate their workers while discretionary bonuses do not, if the rate with which information about firms' cheating behaviour flows in the labour market is relatively low, there exists a range for the number of firms, over and above the critical threshold with discretionary bonuses, for which firms can make positive profits only by paying efficiency wages.

Appendix

A.1 Proof of Result 1

Proof. By differentiating the efficiency wage $\widehat{w} = e^h + \left(e^h - e^l\right)\alpha$ with respect to m yields:

$$\frac{\partial \widehat{w}}{\partial m} = \left(e^h - e^l\right)\frac{\partial \alpha}{\partial m} \gtreqless 0 \Leftrightarrow \frac{\partial \alpha}{\partial m} \gtreqless 0 \tag{32}$$

where

$$\frac{\partial \alpha}{\partial m} = \frac{\theta(r+m)^2 - (1-\theta)rs}{(r+m)^2 x} \tag{33}$$

whose sign depends on that of the r.h.s. numerator.

In particular, if $n \geq \overline{n}$ (hence, $\theta \approx 1$), it is easy to verify that $\frac{\partial \alpha}{\partial m}\mid_{n\geq\overline{n}} \approx \frac{1}{x} > 0$, hence (in line with Shapiro and Stiglitz (1984)) $\frac{\partial \widehat{w}}{\partial m}\mid_{n\geq\overline{n}} > 0$. Instead, if $n = 1$ and $\theta = 0$, we have that $\frac{\partial \alpha}{\partial m}\mid_{n=1} = -\frac{rs}{(r+m)^2 x} < 0$, hence $\frac{\partial \widehat{w}}{\partial m}\mid_{n=1} < 0$.

Moreover, noting from Eq. (33) that $\frac{\partial \alpha}{\partial m}$ is increasing in θ and taking into account, from Assumption 1, that θ is continuous and non-decreasing in n, there will be a number of firms $\underline{n}^m \in (1, \overline{n})$ such that:

$$\frac{\partial \widehat{w}}{\partial m} \lesseqgtr 0 \Leftrightarrow n \lesseqgtr \underline{n}^m. \tag{34}$$

■

A.2 Proof of Result 3

Proof. By differentiating the efficiency wage $\widehat{w} = e^h + \left(e^h - e^l\right)\alpha$ with respect to n yields:

$$\frac{\partial \widehat{w}}{\partial n} = \left(e^h - e^l\right)\frac{\partial \alpha}{\partial n} \gtreqless 0 \Leftrightarrow \frac{\partial \alpha}{\partial n} \gtreqless 0 \tag{35}$$

where

$$\frac{\partial \alpha}{\partial n} = \underbrace{\frac{\theta'(n)m(r+s+m)(r+m)}{(r+m)^2 x}}_{\text{vanishing reputation effect}} \underbrace{\underbrace{+\frac{\theta\frac{\partial m}{\partial n}(r+m)^2}{(r+m)^2 x}}_{\text{standard "SS" effect}} \underbrace{-\frac{(1-\theta)\frac{\partial m}{\partial n}rs}{(r+m)^2 x}}_{\text{"reputation" effect}}}_{\text{increasing matching probability effect}}. \tag{36}$$

An increase in n increases the matching probability m which, in turn, produces two opposite effects. The first is the standard Shapiro-Stiglitz (SS) effect, according to which reducing unemployment increases the efficiency wage. Clearly, the higher is θ (i.e. the weaker the role of workers' reputation in the labour market) the stronger is this effect. Instead, the second effect (labelled in Eq. (36) as "reputation" effect), which is higher as θ decreases, reflects the role played by workers' reputation on the efficiency wage. This is negative because, when reputation matters, the higher is n (hence, m), the higher the "opportunity cost" of shirking. However, an increase in n does not only affect m, but it also increases θ, which, in turn, affects the wage rent α. This effect is captured by the first term of Eq. (36) and, since it operates to reduce the role of workers' reputation, it clearly reinforces the standard SS effect against to the reputation effect.

Taking Eq. (33) into account, also note that Eq. (36) can be rewritten as:

$$\frac{\partial \alpha}{\partial n} = \theta'(n)\frac{\partial \alpha}{\partial \theta} + \frac{\partial m}{\partial n}\frac{\partial \alpha}{\partial m} \tag{37}$$

that, first of all, can be negative only if $\frac{\partial \alpha}{\partial m} < 0$. As shown in Section A.1, this can apply only if n is sufficiently low ($n < \underline{n}^m$). Moreover, to be $\frac{\partial \alpha}{\partial n} < 0$, the following condition (with $\frac{\partial \alpha}{\partial m} < 0$) also needs to be satisfied:

$$\theta'(n)\frac{\partial\alpha}{\partial\theta} < \frac{\partial m}{\partial n}\frac{\partial\alpha}{\partial m}. \qquad (38)$$

That is, $\frac{\partial\alpha}{\partial n} < 0$ only if the (negative) effect operating via increasing m outweighs the (positive) effect operating via vanishing workers' reputation (i.e. increasing θ).

To proof that, with efficiency wages, the industry total wage bill, $(\sum \widehat{w})$, always increases with n (even when $\frac{\partial\widehat{w}}{\partial n} < 0$ for some n), recall that $\frac{\partial(\sum\widehat{w})}{\partial n} = e^h + (e^h - e^l)\left(\alpha + n\frac{\partial\alpha}{\partial n}\right)$, where $e^h + (e^h - e^l)\alpha$ is the wage paid by the marginal firm, while $(e^h - e^l)n\frac{\partial\alpha}{\partial n}$ is the total variation of wages paid by infra-marginal firms.

From Eqs. (15) and (36), we know that:

$$\alpha + n\frac{\partial\alpha}{\partial n} = \frac{(r+\theta m)(r+s+m)(r+m) - n(1-\theta)\frac{\partial m}{\partial n}rs}{(r+m)^2 x} + n\Psi \qquad (39)$$

where $\Psi \equiv \frac{\theta'(n)m(r+s+m)}{(r+m)x} + \frac{\theta\frac{\partial m}{\partial n}}{x} > 0$. Using Eq. (5) and defining $\Omega \equiv \ell - (1-s)n$, the r.h.s. of Eq. (39) can be rewritten as:

$$\frac{\left(\frac{r\Omega+s\theta n}{\Omega}\right)\left(\frac{r\Omega+s(\ell+sn)}{\Omega}\right)\left(\frac{r\Omega+sn}{\Omega}\right) - \frac{(1-\theta)rs^2\ell n}{\Omega^2}}{\left(\frac{r\Omega+sn}{\Omega}\right)^2 x} + n\Psi \qquad (40)$$

which, using some algebra, becomes:

$$\frac{r\Omega\left\{r\Omega\left[r\Omega + s((\ell+n(1+s))(1+s\theta n)+\theta n)\right] + s^2 n\left[\theta\ell(1+sn)+sn(1+s\theta n)\right]\right\}}{\left(\frac{r\Omega+sn}{\Omega}\right)^2 x}$$
$$+ n\Psi > 0. \qquad (41)$$

Hence, for any n, $\frac{\partial(\sum\widehat{w})}{\partial n} = e^h + (e^h - e^l)\left(\alpha + n\frac{\partial\alpha}{\partial n}\right) > 0$. ■

A.3 Proof of Result 4

Proof. Industry profits can be higher when firms elicit workers' effort by adopting efficiency wages instead of discretionary bonuses only if, under efficiency wages, they are positive for $n = \tilde{n}$, that is, for the number of competing firms for which profits collapse to zero with discretionary bonuses. By substituting for $n = \tilde{n}$ (Eq. (24)) in the industry profits with efficiency wages (Eq. (27)), and defining with $\tilde{\alpha}$ the corresponding wage rent (per unit of "extra" effort), we get:

$$\left(\sum \pi\right)_{EW} |_{n=\tilde{n}} = \tilde{n} \left\{ \frac{a^2}{\left[\frac{a}{\sqrt{c\left(e^h + \frac{r}{z}\frac{e^h - e^l}{x}\right)}}\right]^2 c} - \left[e^h + \left(e^h - e^l\right)\tilde{\alpha}\right] \right\} \tag{42}$$

which, using some algebra, becomes:

$$\left(\sum \pi\right)_{EW} |_{n=\tilde{n}} = \tilde{n}\left(e^h - e^l\right)\left(\frac{r}{zx} - \tilde{\alpha}\right). \tag{43}$$

Eq. (43) is strictly positive for:

$$z < \frac{r}{x\tilde{\alpha}} \tag{44}$$

or (taking into account that $\tilde{\alpha} \equiv \frac{(r+\tilde{\theta}\tilde{m})(r+s+\tilde{m})}{(r+\tilde{m})x}$):

$$z < \frac{r(r+\tilde{m})}{(r+\tilde{\theta}\tilde{m})(r+s+\tilde{m})}. \tag{45}$$

Also note that Eq. (45) is always satisfied when $z \to 0$. This is because implicit contracts, in such a case, cannot be made self-enforcing. Hence industry profits can never be positive with discretionary bonuses. Instead, Eq. (45) is never satisfied for $z \to 1$, because $\tilde{n}$ becomes too high for industry profits to be positive (for such a number of firms) with efficiency wages. ■

References

Baker G. (1992), Incentive contracts and performance measurement, *Journal of Political Economy* 100: 598-614.

Bewley T. (1999), *Why Wages Don't Fall During a Recession*, Cambridge: Harvard University Press.

Blanchard O. and Fischer S. (1989), *Lectures in Macroeconomics*, Cambridge (MA): MIT Press.

Bull C. (1987), The existence of self-enforcing implicit contracts, *Quarterly Journal of Economics*102: 147-159.

Calvo G. and Wellisz S. (1978), Supervision, loss of control and the optimal size of the firm, *Journal of Political Economy* 86: 943-952.

Carmichael L. (1984), Reputations in the labor market, *American Economic Review* 74: 713-725.

Cuñat V. and Guadalupe M. (2005), How does product market competition shape incentive contracts? *Journal of the European Economic Association* 3: 1058-1082.

Doeringer P. and Piore M. (1971), *Internal Labour Markets and Manpower Analysis*, Lexington: Heat Lexington Books.

Dowrick S.J. (1989), Union-oligopoly bargaining, *Economic Journal* 99: 1123-1142.

Fershtman C. (1985), Managerial incentives as a strategic variable in duopolistic environment. *International Journal of Industrial Organization* 3: 245-253.

Fershtman C. and Judd K. (1987), Equilibrium incentives in oligopoly, *American Economic Review* 77: 927-940.

Hart O. and Holmström B. (1987), The theory of contracts. In Bewley T. (ed.) *Advances in Economic Theory: Fifth World Congress*, Cambridge: Cambridge University Press.

Hogan C. (2001), Enforcement of implicit employment contracts through unionization, *Journal of Labor Economics* 19: 171-195.

Holmström B. and Milgrom P. (1991), Multitask principal-agent analyses: incentive contracts, asset ownership, and job design, *Journal of Law, Economics, and Organization* 7: 24-52.

Horn H. and Wolinsky A. (1988), Bilateral monopolies and incentives for mergers, *RAND Journal of Economics* 19: 408-419.

Kreps D.and Wilson R. (1982), Reputation and imperfect information, *Journal of Economic Theory* 27: 253-279.

Levin J. (2002), Multilateral contracting and the employment relationship, *Quarterly Journal of Economics* 117: 1075-103.

MacLeod B. and Malcomson J. (1989), Implicit contracts, incentive compatibility, and involuntary unemployment, *Econometrica* 57: 447-480.

MacLeod B. and Malcomson J. (1998), Motivation and markets, *American Economic Review* 88: 388-411.

Malcomson J. (1999), Individual employment contracts. In Ashenfelter O. and Card D. (eds.) *The Handbook of Labor Economics*, vol. 3B, Amsterdam: North-Holland.

Matsushima N. (2006), Industry profits and free entry in input markets, *Economics Letters* 93: 329-336.

Naylor R. (1999), Union wage strategies and international trade, *Economic Journal* 109: 102-125.

Naylor R. (2002), Industry profits and competition under bilateral oligopoly, *Economics Letters* 77: 169-175.

Ramey G. and Watson J. (1997), Contractual fragility, job destruction, and business cycles, *Quarterly Journal of Economics* 112: 873-911.

Raith M. (2003), Competition, risk and managerial incentives, *American Economic Review* 93: 1425-1436.

Scoppa V. (2003), The role of turnover costs in the enforcement of performance related pay contracts, *Metroeconomica* 54: 60-78.

Shapiro C. and Stiglitz J. (1984), Equilibrium unemployment as a worker discipline device, *American Economic Review* 74: 433-444.

Sklivas S.D. (1987), The strategic choice of managerial incentives, *RAND*

Journal of Economics 18: 206-217.

Schmidt K.M. (1997), Managerial incentives and product market competition, *Review of Economic Studies* 64: 191–213.

Tadelis S. (1999), What's in the name? Reputation as a tradeable asset, *American Economic Review* 89: 548-563.

Tirole J. (1996), A theory of collective reputation (with application to the persistence of corruption and to firm quality), *Review of Economic Studies* 63: 1-22.

Vickers J. (1985),. Delegation and the theory of the firm, *Economic Journal* 95: 138-147.

Williamson O., Wachter M. and Harris J. (1975), Understanding the employment relation: the analysis of idiosyncratic exchange, *Bell Journal of Economics* 6: 250-278.