Informal incentive labour contracts and product market competition*

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Abstract

This paper studies the dynamic interaction between product market competition and incentives against shirking. In contrast with standard results, efficiency wages paid by each firm can decrease when competition (i.e. the number of firms in the product market) increases. Discretionary bonuses, on the other hand, do not vary with competition. There is an upper threshold for the number of competing firms, however, above which such schemes are no longer sustainable as an equilibrium. Industry profits with bonuses are generally higher than with efficiency wages but, when information regarding firms' misbehaviour flows at a low rate, a competition range exists for which firms can make a positive profit by only paying efficiency wages.

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1 Introduction

As is well known, the difficulty of measuring individual performance objectively limits the use of legally enforceable incentive contracts and means that firms often rely on informal agreements to motivate employees.[1] Considerable attention has been devoted to two alternative incentive schemes, namely, efficiency wages and discretionary bonuses, which have been largely studied and compared by the literature (see, in particular, Shapiro and Stiglitz 1984; MacLeod and Malcomson 1989, 1998).[2]

This paper is aimed at extending the previous literature on informal incentive labour contracts by introducing the role of imperfect (Cournot) competition in the product market. While previous works have concentrated on the labour market and implicitly assumed that product markets, where firms operate, are perfectly competitive, we analyze the dynamic interaction between product market competition and incentives against shirking. Indeed, in order to provide parties with incentives to fulfil informal labour contracts, the degree of competition in the product market can play an important role in various ways.

The questions addressed here include the following: does competition in the product market affect wage profiles, and if so, how does this relate to the incentive scheme adopted by firms? What relationship should we expect to find between product market competition and industry profits, in terms of alternative incentive contracts? Since with efficiency wages firms have to pay a rent to motivate their workers, but do not have to with discretionary bonuses, are profits always higher with bonuses? Or, does the degree of product market competition affect the relative profitability of alternative schemes? In addition, while the standard shirking model of efficiency wages predicts a positive clear-cut relationship between wages and employment, and it is clear that employment increases with the number of competing firms, empirical evidence on the connection between wages and product mar-

[1] Such informal agreements or contracts are also referred to as "self-enforcing implicit contracts" (e.g. Bull 1987) or "relational contracts" (e.g. Levin 2003).

[2] As pointed out by MacLeod and Malcomson (1989, p. 448), efficiency wage contracts also have their own informal or implicit element, namely "that the employee will perform satisfactorily if employed and that the employer will continue the contract if performance is satisfactory, or terminate it if not".

ket competition is mixed (e.g. Blanchflower 1986; Dickens and Katz 1987; Nickell et al. 1994, as well as the literature cited therein). Thus, could introducing product market competition into a shirking model modify its standard prediction regarding the wage-employment nexus? All these issues are obviously relevant to the concerns of labour economics and industrial organization.

We also introduce an important issue with respect to the standard hypothesis regarding the reputation of workers. We will assume that workers who have been previously fired as the result of shirking *may* have a lower probability of finding a new job with respect to other workers and, more importantly, we relate such a possibility to the number of firms competing in the product market. As we will discuss, detecting shirkers in the unemployment pool (i.e. establishing a worker's reputation) becomes more difficult as the number of firms in the market increases.[3]

Our main results can be summarized as follows. Firstly, equilibrium efficiency wages may be decreasing in the probability of unemployed workers finding a job, as well as when competition and employment increase. Such outcomes, which are in contrast with Shapiro and Stiglitz (1984), are a result of the fact that when the number of firms in the market increases, the probability of workers finding a job becomes larger. In turn, when a worker's reputation plays a role, this also increases the "opportunity-cost" of shirking and enables firms to get workers to perform well even with a lower wage.

When firms adopt discretionary bonuses, on the other hand, workers' wages are generally uncorrelated with competition in the product market. However, there is a critical threshold for the number of competing firms above which discretionary bonuses are no longer sustainable as an equilibrium. This is because a firm's profit becomes too low for its promise to pay the bonus to be credible. This threshold relates to product market as well as labour market parameters.

The above results also lend themselves to a comparative analysis of the relationship between the two incentive schemes considered and (industry) profits. In general, since efficiency wages mean that a firm pays a rent to motivate their workers, which does not apply to discretionary bonuses, prof-

[3]The role of workers' reputation in affecting *unverifiable* performance is discussed in Malcomson (1999), however it is not related to the degree of product market competition.

its are higher with the latter. However, when information about a firm's misbehaviour flows at a (relatively) low rate in the labour market, there is a range of the number of firms, over and above the critical threshold with bonuses, for which an equilibrium with positive profits does exist only with efficiency wages.

Our work relates to (and largely draws from) the informal contracts literature. Most notably, MacLeod and Malcomson (1998) model the choice between efficiency wages and performance pay as a function of *labour market* conditions. They show that, when there are unemployed workers, at an efficient equilibrium the rent required to make the agreement self-enforcing must go to the worker in the form of a high (efficiency) wage while, if there are unfilled vacancies, efficient market equilibrium has performance pay.[4] In contrast to MacLeod and Malcomson (1998), our aim is to compare efficiency wages and performance pay in relation to product (instead of labour) market conditions.

This paper also deals with the literature that, starting from Machlup (1967), studies how product market competition interacts with incentive contracts in motivating managers and other workers (e.g. Schmidt 1997; Raith 2003; see Legros and Newman 2011 for a recent survey). This literature, however, differs from our work mainly because it considers principal-agent problems where *formal* incentive contracts (linking pay to performance) are feasible, and analyzes changes in the optimal "shape" of incentive contracts following changes in product market competition. In contrast, we consider the interaction between incentive labour contracts and imperfect product market competition in a context in which formal incentive contracts are not feasible.[5]

The relationship between the number of firms competing in the (oligopolis-

[4]Meccheri (2005) compares efficiency wages, discretionary bonuses and tournaments in terms of employment outcomes.

[5]See Cuñat and Guadalupe (2005) for an empirical study on the relationship between product market competition and compensation packages. They also recognize that the evidence regarding the relationship between product market competition and incentive pay is still very limited, which is particularly true for the case of informal incentive contracts. In this paper, we will provide some novel theoretical predictions on the relationship between informal labour contracts and product market competition, which could be suitable for testing empirically (see, in particular, the discussion in the concluding section).

tic) product market, wages and (industry) profits has also been examined in relation to unionized oligopolies (e.g. Dowrick 1989; Naylor 2002; Bastos et al. 2010; Mukherjee 2012). However, in these studies, the effects of competition on wages operate by affecting the rents that the unions bargain with while, within our framework, these effects relate to the changes in the optimal incentive wage contract.

The rest of the paper is organized as follows: in Section 2 the basic framework is described. The competition game in the product market and the design of alternative (incentive) labour contracts are examined in Section 3. Section 4 compares their outcomes in relation to the effects on industry profits. Section 5 draws some conclusions, while further details and technical proofs are provided in the Appendix.

2 Model

2.1 Economic environment

Time is discrete, $t = 1, 2, ...$[6] There is a number $n \geq 1$ of identical firms competing *à la* Cournot repeatedly over time in a homogeneous good market, with an inverse demand function given by:

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

where Q is the overall market output. 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 an employment relationship over a certain period and interact until their relationship is severed. Given the substantial turnover of jobs in labour markets (Davis and Haltiwanger 1999), in each period employment relationships become unprofitable at a rate s for exogenous reasons and in such cases, firm and employee separate. Firms and workers have an infinite life, they are risk-neutral and discount the future with the same rate r. For simplicity's sake, we concentrate on a situation in which each firm employs one individual worker (e.g. a

[6] Since in this environment the technology, the preferences and all other variables are stationary, we do not need to denote variables by a time index.

manager) and all marginal costs, other than the worker's wage, are constant and normalized to zero.

With regard to labour contracts and workers' effort, we follow MacLeod and Malcomson (1989, 1998) by assuming that: i) firms *perfectly observe* their workers' decisions regarding effort, but the only legally verifiable pieces of information that can be included in a labour contract are money payments and whether or not a person is employed by a firm; and ii) in relation to the worker employed by firm i, the decision regarding effort consists in each period of either working ($e_i = 1$) or shirking ($e_i = 0$), thus obtaining an utility given by:

$$u_i = w_i - ve_i \tag{2}$$

where w_i is the wage paid by firm i and $v > 0$ is the disutility of work, while we normalize the utility of the worker when unemployed to zero.[7]

Obviously, the worker's decision is essential for production and, in particular, we assume that:

$$q_i = \begin{cases} 0 & \text{if } \ e_i = 0 \\ \arg\max \pi_i & \text{if } \ e_i = 1 \end{cases} \tag{3}$$

where π_i is the firm i's per-period profit. This means that, while a worker's decision to work ensures a level of output that maximizes the firm's profit (which will be derived below in detail), there is no production for the firm when the worker shirks.

2.2 Worker's reputation

We admit the possibility that a worker's reputation *can* be established to some extent and, most importantly, we relate such a possibility to the number of firms competing in the product market. We hypothesize that, once a match has occurred, a firm does not hire a worker when it finds out that

[7]We consider product market-specific skills or other sources of mobility costs for workers across sectors. This means that "segmented" labour markets exist in relation to different product markets (e.g. Reich et al. 1973). However, this is not essential for our results. Alternatively, a workers reservation utility (normalized to zero) can be interpreted as the utility of self-employment or employment in other industries where formal incentive contracts are feasible.

the latter is a shirker, that is, he/she has previously been fired for shirking. However, we consider that a worker's previous history is "soft" information (i.e. information that is not based on hard evidence) which flows into the market more and more opaquely as the number of competing firms increases.

In order to understand the rationale behind this assumption, consider the extreme case of a monopoly. Since a worker who has been fired for shirking could only find another job in this market with the same firm (the monopoly), the firm will certainly be aware that the worker is a shirker. On the other hand, if there are many firms in the market, that is, the product market is extremely competitive, it may be more complex for firms to detect shirkers.

This is in line with the literature stressing the importance of information regarding a worker's previous performance being transmitted, essentially by word-of-mouth, through social networks or informal channels (e.g. Rees 1966; Granovetter 1974; Montgomery 1991). Indeed, when recruiting new workers, social networks between firms tend to lead to more efficient hiring outcomes. At the same time, when firms rely exclusively on their social contacts, they lose the opportunity to get information from agents outside their own network (Burt 1992; Schram et al. 2010 provide a recent experimental study on how firms choose between formal and informal recruitment channels). Given that building up social links is costly, the larger the overall number of firms, the higher the probability that a firm is not linked to (hence, does not communicate with) others in the market. Thus, in these cases, it is more likely for a shirker to find another job in firms that do not belong to his/her previous employer's social network.

In addition, the larger the number of firms in the product market, the higher the job turnover, that is, the number of workers who, in each period, lose their jobs for exogenous (not related to shirking) reasons. This could make it more difficult for firms to identify shirkers among all the workers that have lost their jobs. In other words, labour turnover obscures the history of the game in repeated employment relationships (Mukherjee 2010).[8]

[8] An anonymous referee correctly argues that, although effort (and output) is not verifiable, it may be possible to assess a worker's effort by learning about his/her firm's output. In fact, this argument provides further rationale to our hypothesis regarding the relationship between a worker's reputation and product market competition. While with few firms it may be simple to learn about a firm's output (e.g. by inferring from the overall output in the market), this becomes impossible when the number of firms is very large.

2.3 Timing, unemployment values and flows

The timing of events for each period is as follows: i) matching occurs between an unmatched firm and worker and, unless the firm finds out that the worker has been previously fired for shirking, an employment relationship is formed; ii) the firm designs a labour incentive contract that may be either an efficiency wage-type or bonus-type; iii) the firm makes a production decision (the product market game) and the worker decides to work or shirk; iv) the firm pays the (contractual) efficiency wage or, if instead the incentive contract provides for a discretionary bonus, decides whether or not to pay the bonus; v) finally, separation occurs either for exogenous reasons or because the firm fires the (shirking) worker.

Starting from a generic period of time and using U^S and U^{NS} to indicate the expected discounted lifetime utility of an unemployed (unmatched) worker who has and has not been previously fired for shirking, respectively, we have (for the sake of brevity, hereafter we omit the index i whenever it is unnecessary):

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

where $k \in \{S, NS\}$, E^k indicates the expected discounted lifetime utility of an employed worker of type k, m is the per-period probability of an unemployed worker to be matched with a firm and, finally, J is an index function, such that $J = 1$ if $k = NS$ and $J = \theta$ if $k = S$.

Specifically, θ represents the probability that, once matched with a firm (which occurs with probability m), a shirker (i.e. a worker previously fired for shirking) *is not* identified as such by the firm. In line with the discussion in Section 2.2 regarding the relationship between a worker's reputation and the number of firms in the product market, the following assumption is established in relation to θ.

Assumption 1 *The function $\theta = \theta(n) \in [0, 1)$, with $\theta(1) = 0$ and $\theta(n) \to 1$ for $n \to \infty$. Furthermore, for any n, $\theta(n)$ is increasing.*

According to Assumption 1, when the product market is perfectly competitive ($n \to \infty$), $\theta \to 1$ and the Shapiro-Stiglitz "anonymous" market hypothesis applies. Instead, when the product market is a monopoly, a worker once fired for shirking is never employed again in this market. Finally, a "worker's reputation" can be established to some extent (depending on n) for intermediate values of n, hence workers previously fired for shirking could get new jobs with a lower (but positive) probability than other workers.

In a stationary equilibrium, all employed workers do not shirk and lose their jobs only for exogenous reasons. Furthermore, movements into and out of unemployment must balance. Accordingly, the matching probability for an unemployed worker is given by:

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

On the other hand, since ℓ is sufficiently large to satisfy whatever labour demand and no search frictions are assumed in this economic environment, in a stationary equilibrium, where all implicit contracts are honoured, each firm promptly finds a new worker when an employment relationship is severed for exogenous reasons. Also note that, in this context, it is natural to assume that firms have all market power *vis-à-vis* their workers.

3 Oligopolistic competition and informal incentive labour contracts

3.1 The product market game

In accordance with 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} is the sum of the quantities supplied by the other firms. Under the Cournot-Nash assumption, the differentiation of (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: $q_i = (a - cQ_{-i})/2c$. Solving all firms' reaction functions simultaneously enables us to derive the symmetric equilibrium firm i's output (with $q_i = q, \forall i$), as:

$$q = \frac{a}{(n+1)c}. \tag{7}$$

By substituting for (7) in (6), we get an expression for the firm i's profit which, in a symmetric equilibrium ($\pi_i = \pi, \forall i$), is given by:

$$\pi = \frac{a^2}{(n+1)^2 c} - w \tag{8}$$

where w $(= w_i, \forall i)$ is the outcome of the game determining the optimal incentive labour contract (which will be studied below). Notice that, due to the fact that wages are (quasi-)fixed costs in this context, profits can be negative for large values of n. In what follows, however, we will generally assume that the product market parameter a is large enough to ensure that results are meaningful.

3.2 The incentive labour contract and wage profiles

3.2.1 Efficiency wages

The best known model in shirking versions of efficiency wages is provided by Shapiro and Stiglitz (1984). By incorporating our hypothesis regarding a workers probability of getting a job, a standard analysis (see Appendix A.1) leads to the following equilibrium efficiency wage:

$$w_{EW} = v\left[\frac{(m+r)(1+\theta m+r)}{m+r-s(\theta m+r)}\right]. \tag{9}$$

Lemma 1 *With s and $r > 0$ and for a sufficiently low n, the efficiency wage decreases when the matching probability m increases.*

Proof. See Appendix A.2. ■

The rationale behind Lemma 1 is quite straightforward. In our framework, two different factors affect the equilibrium wage when m increases. On the one hand, by making losing a job less severe for *all* workers, it forces firms to pay higher wages to motivate them. This is the standard "Shapiro-Stiglitz effect", which is clearly stronger when the role of a worker's reputation is weaker (n is higher) and there is not too much difference for workers between losing a job due to shirking or for exogenous reasons.

On the other hand, however, an increase in m also increases the "opportunity-cost" of shirking. This is because it increases the differential probability of getting another job between non-shirkers and shirkers. This "reputation effect" operates against the Shapiro-Stiglitz effect, enabling firms to elicit effort from workers, even with a lower wage. Furthermore, the lower n, the stronger the role played by the reputation effect. Thus, when m increases and n is sufficiently low, the reputation effect outweighs the Shapiro-Stiglitz effect, hence reducing the equilibrium wage.[9]

In addition, since an increase in the number of firms increases the (steady-state) matching probability m, it is interesting to investigate whether a negative relationship could also exist between the equilibrium efficiency wage and n. Notice that, in our framework, an increase in n also involves a decrease in unemployment. Thus this negative relationship would imply a reversal in the standard result that, in equilibrium, efficiency wages and unemployment are always negatively correlated.

Result 1 *When competition is low and the effect of changing competition on a workers reputation is sufficiently small, a critical n exists below which the efficiency wage decreases when competition becomes fiercer (i.e. n increases) and above which the opposite applies. However, the total industry wage bill (i.e. the sum of firms' wages) always increases with n.*

Proof. See Appendix A.3. ■

While a complete formal proof of Result 1 is provided in the final appendix, in order to understand the rationale behind it, let us define with α the term in brackets of (9)'s r.h.s., which represents the key term of the equilibrium efficiency wage. By differentiating α with respect to n:

$$\frac{\partial \alpha}{\partial n} = \underbrace{\theta'(n)\frac{\partial \alpha}{\partial \theta}}_{\text{changing } \theta \text{ effect } (+)} + \underbrace{\frac{\partial m}{\partial n}\frac{\partial \alpha}{\partial m}}_{\text{changing } m \text{ effect } (+/-)} . \tag{10}$$

[9]As formally shown in Appendix A.2, this result can never apply whenever s (and r) = 0. This is because, in such a case, a higher matching probability m only benefits shirkers, hence unambiguously leads to a higher efficiency wage. Also note that while here we concentrate on product market competition (highlighting the novel role it plays in affecting wages), an analogous result would be obtained for other (not related to competition) reasons which cause a sufficiently large difference between the job-finding rates of shirkers with respect to non-shirkers.

An increase in competition increases employment, thus leading to an increase in the matching probability m. In turn, as discussed above in Lemma 1, the resulting effect on the equilibrium wage can be disentangled, by distinguishing between the "Shapiro-Stiglitz effect" and the "reputation effect", which operate against one another. However, besides increasing m, an increase in n also produces another important effect, namely it increases θ. That is, it reduces the role of the workers' reputation. In turn, by lowering the cost of shirking, this drives firms to pay a higher rent to motivate their workers.[10] Thus, we can conclude that, when n increseas, the equilibrium wage actually decreases if (and only if): i) the "changing m effect" is negative (which requires that competition is sufficiently low); *and* ii) the "changing θ effect" is so small that the "changing m effect" prevails.

Finally, note that Result 1 also states that even if $\partial\alpha/\partial n < 0$, only wages paid by infra-marginal firms decrease, while the total industry wage bill increases. This is because the total wage reduction for infra-marginal firms is always lower than the wage paid by the marginal firm.[11]

3.2.2 Discretionary bonuses

Let us now consider an incentive scheme that provides for a bonus payment that is conditional on the worker's choice regarding effort (e.g. Bull 1987; MacLeod and Malcomson 1989). Generally, together with the bonus that represents the implicit part of the contract, the latter also provides for a fixed salary, whose payment can be enforced by a court. Since in our framework firms have all the bargaining power *vis-à-vis* the workers, firms fix the salary such that, given the equilibrium bonus, workers exactly receive their oppor-

[10] Overall, the effect of an increase of n on the equilibrium wage via increasing θ is captured by the first term of (10), which is always positive. It is worth noting that (10) also provides some intuitions on the possibility of testing Assumption 1 ($\theta'(n) > 0$) by means of wage (rent) data across sectors, suggesting that, when Assumption 1 applies, wage rents should increase with n. Obviously, this needs to control for job-finding rates across sectors as well as several other variables, which is a non-trivial issue. This is because many factors, which are correlated with the degree of industrial concentration, can affect wage rents for workers (e.g. the presence and the structure of unionization).

[11] In the working paper version (Meccheri and Fanti 2012), we provide some illustrations based on simulation results, which confirm such outcomes. They are not reported here for reasons of space.

tunity cost. Hence, the salary equals the workers' reservation utility, which is normalized to zero, permitting us to concentrate, without loss of generality, only on the bonus. In Appendix A.1, where further details regarding firms' and workers' strategies are provided, we show that the equilibrium bonus chosen by firms is:

$$w_B = v. \tag{11}$$

Note that, unlike the efficiency wages case, with discretionary bonuses: i) the wage does not depend on the number of firms competing in the product market; and ii) firms can potentially motivate workers without providing them with a rent (Malcomson 1999). Furthermore, θ, hence a worker's reputation, never plays a role in providing incentives. This is because, in the equilibrium with bonuses, employed workers receive exactly the same utility as unemployed workers.

However, firms must be able to credibly commit themselves to paying the bonus, which requires the information about a firm's misbehaviour flows, at least to some extent, in the (labour) market. Labour unions, for instance, can contribute by monitoring the employment relationships between a firm and its workers, and by providing the workforce with valuable information regarding the firm's adherence to implicit contracts (Hogan 2001). In addition, firms themselves could have an interest in credibly fostering the transmission of this information to the market since, by committing themselves more strongly, they can offer a broader range of incentives (Kreps and Wilson 1982; Tirole 1996; Tadelis 1999).

We will consider a situation in which information on a firm's misbehaviour flows in the labour market at a per-period rate $z < 1$. Nevertheless, whenever this occurs, a firm's reneging is interpreted by the labour workforce as a whole as evidence that a firm does not fulfil informal agreements with its workers, meaning that no worker will be motivated to work for that firm in the future (Doering and Piore 1971; Bewley 1999).[12]

[12]It could be argued that, since we have related θ (which captures how workers' reputations flow in the market) to the number of competing firms, this could also be done for z. However, difficulties in external agents verifying whether a monopolist has promised to pay a bonus or whether the latter was actually paid appear to be exactly the same as for an individual firm in a more competitive setting. Furthermore, since we postulate that θ

Under this assumption regarding a firm's reputation, the following condition, as derived in Appendix A.1, must be satisfied in order to make agreements on bonuses self-enforceable:

$$\pi \geq \frac{rv}{z}. \tag{12}$$

Taking into account (8), the equilibrium value for the firm's profit in the product market game, and solving for n, we obtain a condition for the number of firms competing in the product market, which must be satisfied in a self-enforcing equilibrium with bonuses:

$$n \leq \tilde{n} \equiv \frac{a}{\sqrt{cv\left(\frac{r+z}{z}\right)}} - 1. \tag{13}$$

Result 2 *An upper threshold exists for the number of firms competing in the product market, over which discretionary bonuses are not sustainable as a self-enforcing equilibrium.*

Since a firm's profits are decreasing in n, (13) establishes an upper constraint for competition in the product market, for which discretionary bonuses are sustainable as a self-enforcing equilibrium. This upper constraint is related to both product market and labour market parameters. The higher a and the lower c (i.e. the higher the scale or size of the product market), the higher the upper constraint n. In addition, the lower the disutility of effort v and the higher the frequency with which information regarding a firm's misbehaviour flows in the labour market z, the higher n. Note that if $z \to 0$ (i.e. a firm's reputation mechanism does not work at all), the firm would never gain anything by sticking to the agreement. Hence there is no (positive) number of firms for which implicit self-enforcing contracts can be established. Finally, for the usual reasons, n also negatively depends on the discount rate r.

depends on n (which relates to the labour market demand), symmetry would imply that z should depend on ℓ (which relates to the labour market supply) instead of n. However, since we consider a situation with unemployed workers ($\ell > n$), ℓ does not play any important role in the analysis that follows, thus there is no loss of generality in considering z as exogenously given instead of as a function of ℓ.

4 Informal incentive schemes, competition and industry profits

In this section, we explore how competition in the product market affects industry profits according to the incentive scheme firms use to motivate their workers. By taking (8), (9) and (11) (as well as (13)) into account, we can easily derive industry profits under the two alternative incentive schemes such as, respectively:

$$\sum \pi_{EW} = n\pi_{EW} = \frac{na^2}{(n+1)^2 c} - nv\alpha \tag{14}$$

$$\sum \pi_B = n\pi_B = \begin{cases} \frac{na^2}{(n+1)^2 c} - nv & \text{if } n \leq \tilde{n} \\ 0 & \text{if } n > \tilde{n}. \end{cases} \tag{15}$$

By differentiating (14) and (15), respectively, with respect to n (and recalling from the proof of Result 1 that $\alpha + n\frac{\partial \alpha}{\partial n} > 0$; see Appendix A.3), it is easy to show that:

$$\frac{\partial \left(\sum \pi_{EW}\right)}{\partial n} = \frac{(1-n)a^2}{(n+1)^3 c} - v(\alpha + n\frac{\partial \alpha}{\partial n}) < 0 \tag{16}$$

$$\frac{\partial \left(\sum \pi_B\right)}{\partial n}|_{n \leq \tilde{n}} = \frac{(1-n)a^2}{(n+1)^3 c} - v < 0 \tag{17}$$

and

$$\left| \frac{\partial \left(\sum \pi_{EW}\right)}{\partial n} \right| > \left| \frac{\partial \left(\sum \pi_B\right)}{\partial n}|_{n \leq \tilde{n}} \right| \tag{18}$$

that is, as n increases, industry profits decrease more rapidly with efficiency wages than with discretionary bonuses.

All the above outcomes suggest that, in general, profits are higher with discretionary bonuses than with efficiency wages. However, as soon as the number of competing firms exceeds $\tilde{n}$, discretionary bonuses become unsustainable as a self-enforcing equilibrium. Figure 1 describes the behaviour of industry profits, 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). Note that, since profits are always decreasing in n with efficiency wages, it can be argued that an upper threshold for n also exists under such an incentive scheme, which corresponds to the value for which profits become zero.

Figure 1: Incentive schemes, competition and industry profits

In Case 1 in Figure 1, industry profits with efficiency wages are already negative when n approaches $\tilde{n}$, that is, the upper bound for n with efficiency wages is lower than $\tilde{n}$. By contrast, in Case 2, the upper bound for n with efficiency wages is higher than with discretionary bonuses. The following result defines the condition for which the latter case actually applies, as well as its main implication.

Result 3 *If the rate z, with which a firm's reputation flows in the labour market, is sufficiently low, the upper bound for n with efficiency wages is higher than with discretionary bonuses. Hence, a range of competing firms exists, over and above $\tilde{n}$, for which an equilibrium with firms' positive profits only exists with efficiency wages.*

Proof. See Appendix A.4. ■

In Appendix A.4 we show that for the critical threshold with efficiency wages to be larger than $\tilde{n}$, the following condition must be satisfied:

$$z < \frac{r}{\tilde{\alpha} - 1} \tag{19}$$

where " ˜ " means that α is evaluated in $n = \tilde{n}$. This makes sense. An equilibrium with positive (industry) profits can exist *only* under efficiency wages if (and only if), under such a scheme, profits are still positive when $n = \tilde{n}$. Since $\sum \pi_{EW}$ (rapidly) decreases in n, this can happen only if $\tilde{n}$ is sufficiently low, which occurs if z is (relatively) low. Moreover, when firms pay efficiency wages, profits decrease with α (the term related to the wage rent). Hence, z should be relatively low with respect to a given threshold, related negatively to $\tilde{\alpha}$. Also note that (19) is always satisfied when $z \to 0$. This is because, in such case, discretionary bonuses cannot be made self-enforcing. Instead, it is never satisfied for $z \to 1$, because $\tilde{n}$ becomes too high for the critical threshold with efficiency wages to be larger.[13]

5 Concluding comments

In this paper, the dynamic interaction between product market competition and incentives against shirking was analyzed within a framework where workers' effort is observable, but is not verifiable by a third party (e.g. a court). In addition, it was assumed that the probability of the unemployed getting a job could depend on their employment histories and, more importantly, that such a possibility was related to the degree of product market competition. Thus the effects of two well-known incentive schemes, namely, efficiency wages and discretionary bonuses, were studied and compared.

In contrast with standard results, we found that efficiency wages paid by a firm can decrease when competition increases. When firms adopt discretionary bonuses on the other hand, wages are uncorrelated with competition in the product market, but an upper threshold exists for the number of competing firms, above which such contracts are not sustainable as a self-enforcing equilibrium. In addition, although efficiency wages involve firms paying a rent to motivate their workers while discretionary bonuses do not, if the rate with which information about a firm's cheating behaviour flows in the labour market is relatively low, a range of competition exists, over and above the critical threshold with bonuses, for which firms can make positive profits by only paying efficiency wages.

Let us conclude with an outline of some empirical issues which can be re-

[13] In this regard, also note that the role of other parameters (particularly, of r) is not clear-cut, since their changes can generate both direct and indirect effects (e.g. increasing α and decreasing $\tilde{n}$ at the same time) which may act against one another.

lated to the above results. Firstly, since in our context there is the possibility that efficiency wages both increase and decrease when competition becomes fiercer, our outcomes appear more in line (with respect to the standard result that predicts a clear-cut positive relationship between wages and employment/competition) with the mixed empirical evidence on the connection between wages and product market competition. Likewise for discretionary bonuses since, in our framework, they are uncorrelated with competition in the product market.

In addition, although empirically enucleating the effect of competition on wages via incentive schemes is complex, our analysis could provide a springboard for new testable hypotheses on incentive contracts. Given that we found that the larger the size of the market, the larger the critical number of firms for which (in equilibrium) profits can be positive with bonuses, we would expect that, for a given (sufficiently high) degree of competition, the probability of observing the use of discretionary bonuses is higher, the "larger" the size of the market (i.e. in markets with higher values of a and lower values of c). Moreover, industry profits behaviour under alternative incentive schemes also seem to suggest that, *ceteris paribus*, we would observe discretionary bonuses in industries with relatively low numbers of firms. On the other hand, (provided that information regarding a firm's misbehaviour flows at a low rate) efficiency wages should emerge, in a time series analysis, when competition becomes fiercer or, in a cross-sectional study, in other industries characterized by a higher degree of competition.

Appendix

A.1 Derivation of equilibrium wages

Efficiency wages

Denoting with w_{EW} the (efficiency) wage paid by the firm and recalling that workers' decisions regarding effort is perfectly observable for firms, hence a shirker is always fired at the end of the period, the expected discounted lifetime utilities for a shirker and for a non-shirker are given by, respectively:[14]

[14] In order to simplify the algebra, we assume that current payoffs of period t realize *at the end* of the period, hence they must also be discounted. This, however, does not have

$$E_{EW}^{S} = \frac{w_{EW}}{1+r} + \frac{U^{S}}{1+r} \Leftrightarrow E_{EW}^{S} = \frac{w_{EW} + U^{S}}{1+r} \tag{A1}$$

$$E_{EW}^{NS} = \frac{w_{EW} - v}{1+r} + \frac{(1-s)E_{EW}^{NS}}{1+r} + \frac{sU^{NS}}{1+r} \Leftrightarrow E_{EW}^{NS} = \frac{w_{EW} - v + sU^{NS}}{r+s}. \tag{A2}$$

The worker will certainly shirk unless $E_{EW}^{NS} \geq E_{EW}^{S}$. Substituting for U^S and U^{NS} from (4) in (A1) and (A2), respectively, rearranging and solving for w_{EW}, we get the following "no-shirking condition"for the worker:

$$w_{EW} \geq v\left[\frac{(m+r)(1+\theta m+r)}{m+r-s(\theta m+r)}\right] \tag{A3}$$

which, in equilibrium, holds with equality because profit-maximizing firms pay the lowest wages consistent with (A3).

Discretionary bonuses

Since effort is perfectly observable, when firms adopt discretionary bonuses to motivate workers, a shirker never receives the bonus payment and is always fired at the end of the period. Hence, denoting the discretionary bonus with w_B, the expected discounted lifetime utilities of a shirker and a non-shirker are, respectively:

$$E_{B}^{S} = \frac{U^{S}}{1+r} \tag{A4}$$

$$E_{B}^{NS} = \frac{w_{B} - v}{1+r} + \frac{(1-s)E_{EW}^{NS}}{1+r} + \frac{sU^{NS}}{1+r} \Leftrightarrow E_{B}^{NS} = \frac{w_{B} - v + sU^{NS}}{r+s}. \tag{A5}$$

Clearly, workers will shirk unless $E_{B}^{NS} \geq E_{B}^{S}$. Solving for the bonus, we get the following incentive-compatibility condition for the worker:

$$w_B \geq v. \tag{A6}$$

Firms choose the lowest bonus compatible with (A6), which, in equilibrium, holds with equality.

Firms, however, must be able to credibly commit themselves to paying the bonus. Consider that workers play a trigger strategy. Thus, a (non-shirker)

any qualitative effect on the points that we make.

worker not receiving a promised bonus will decide not to exert any effort for the firm in the future. However, since the firm's profit is negative when workers shirk, it is always better for a firm to end the employment relationship and look for another applicant than let the relationship continue with no effort by the worker in the future. However, according to the hypothesis regarding a firm's reputation described in the main text, the possibility for a "cheating" firm to get another worker occurs at the rate $1 - z$.

Hence, the expected discounted profits for a "cheating" firm and for a "non-cheating" firm (that honestly pays the bonus) are, respectively:

$$\Pi^C = \frac{\pi + w_B}{1+r} + \frac{(1-z)\Pi^C}{1+r} \Leftrightarrow \Pi^C = \frac{\pi + w_B}{r+z} \tag{A7}$$

$$\Pi^{NC} = \frac{\pi}{1+r} + \frac{\Pi^{NC}}{1+r} \Leftrightarrow \Pi^{NC} = \frac{\pi}{r}. \tag{A8}$$

The firm cheats on the bonus payment unless $\Pi^{NC} \geq \Pi^C$. Solving for π, we obtain the following "no-cheating" condition for the firm:

$$\pi \geq \frac{rw_B}{z}. \tag{A9}$$

Finally, in order to define the aggregate condition that makes implicit agreements with bonuses self-enforceable, we add (A6) to (A9) and, taking into account that the firm makes the lowest payments, we get:

$$\pi \geq \frac{rv}{z}. \tag{A10}$$

A.2 Proof of Lemma 1

Proof. By differentiating the efficiency wage $w_{EW} = v\alpha$ with respect to m yields:

$$\frac{\partial w_{EW}}{\partial m} = v\frac{\partial \alpha}{\partial m} \gtreqless 0 \Leftrightarrow \frac{\partial \alpha}{\partial m} \gtreqless 0 \tag{A11}$$

where

$$\frac{\partial \alpha}{\partial m} = \underbrace{\frac{\theta(m+r)\left[m+r-s(\theta m+r)\right]}{\left[m+r-s(\theta m+r)\right]^2}}_{\text{Shapiro-Stiglitz effect } (+)} - \underbrace{\frac{(1-\theta)rs(1+\theta m+r)}{\left[m+r-s(\theta m+r)\right]^2}}_{\text{reputation effect } (-)}. \tag{A12}$$

In particular, if $n \to \infty$, $\partial\alpha/\partial m > 0$. Instead, if $n = 1$, we have that $\partial\alpha/\partial m < 0$. Moreover, noting from (A12) that $\partial\alpha/\partial m$ is increasing in θ and taking into account, from Assumption 1, that θ is increasing in n, there will be a number of firms $\underline{n}^m \in (1, \infty)$ such that:

$$\frac{\partial w_{EW}}{\partial m} \lesseqgtr 0 \Leftrightarrow n \lesseqgtr \underline{n}^m. \tag{A13}$$

■

A.3 Proof of Result 1

Proof. By differentiating the efficiency wage $w_{EW} = v\alpha$ with respect to n yields:

$$\frac{\partial w_{EW}}{\partial n} = v\frac{\partial \alpha}{\partial n} \gtreqless 0 \Leftrightarrow \frac{\partial \alpha}{\partial n} \gtreqless 0 \tag{A14}$$

where:

$$\partial\alpha/\partial n =$$

$$\underbrace{\frac{\theta'(n)m(m+r)(m+r+s)}{[m+r-s(\theta m+r)]^2}}_{\underbrace{\theta'(n)\frac{\partial\alpha}{\partial\theta}}_{\text{changing } \theta \text{ effect}}} + \underbrace{\frac{\partial m}{\partial n}\left[\underbrace{\frac{\theta(m+r)\left[m+r-s(\theta m+r)\right]}{[m+r-s(\theta m+r)]^2}}_{\text{standard Shapiro-Stiglitz effect}} - \underbrace{\frac{(1-\theta)rs(1+\theta m+r)}{[m+r-s(\theta m+r)]^2}}_{\text{reputation effect}}\right]}_{\underbrace{\frac{\partial m}{\partial n}\frac{\partial\alpha}{\partial m}}_{\text{changing } m \text{ effect}}}. \tag{A15}$$

First of all, notice that, since $\theta'(n) > 0$, $\partial\alpha/\partial\theta > 0$ and $\partial m/\partial n > 0$, (A15) can be negative only if $\partial\alpha/\partial m < 0$. As shown in Section A.2, this can apply only if n is sufficiently low ($n < \underline{n}^m$). However, this is a necessary but not sufficient condition. Indeed, to be $\partial\alpha/\partial n < 0$, the following condition (with $\partial\alpha/\partial m < 0$) also needs to be satisfied:

$$\theta'(n)\frac{\partial\alpha}{\partial\theta} < \left|\frac{\partial m}{\partial n}\frac{\partial\alpha}{\partial m}\right|. \tag{A16}$$

To proof that the industry total wage bill, $\sum w_{EW}$, always increases with n, recall that $\partial\left(\sum w_{EW}\right)/\partial n = v\left[\alpha + n(\partial\alpha/\partial n)\right]$, where $v\alpha$ is the wage paid by the marginal firm, while $nv(\partial\alpha/\partial n)$ is the total variation of wages paid by infra-marginal firms.

From (9) and (A15), we know that:

$$\alpha + n\frac{\partial \alpha}{\partial n} = \frac{(r+m)(1+\theta m + r)}{m+r-s(\theta m + r)} - \frac{n(1-\theta)\frac{\partial m}{\partial n} rs(1+\theta m + r)}{[m+r-s(\theta m + r)]^2} + n\Psi \quad \text{(A17)}$$

where $\Psi \equiv \frac{\theta'(n)m(m+r)(m+r+s)}{[m+r-s(\theta m+r)]^2} + \frac{\theta \frac{\partial m}{\partial n}(m+r)}{m+r-s(\theta m+r)} > 0.$

Using (5) and defining $\Omega \equiv \ell - (1-s)n > 0$, the r.h.s. of (A17) can be rewritten as:

$$\frac{1+\theta m + r}{[m+r-s(\theta m+r)]^2} \times$$

$$\left[\left(\frac{r\Omega + sn}{\Omega}\right)\left(\frac{r\Omega(1-s)+sn(1-\theta s)}{\Omega}\right) - \frac{n(1-\theta)rs^2\ell}{\Omega^2}\right] + n\Psi \qquad \text{(A18)}$$

which, with some tedious algebra (details available on request), becomes:

$$\frac{1+\theta m + r}{[m+r-s(\theta m+r)]^2} \times$$

$$\left\{\frac{r\Omega\left[(r\Omega + sn)(1-s) + sn[r(1-s)(\ell - n)]\right] + s^2n^2\left[1+\theta r(1-s) - \theta s\right]}{\Omega^2}\right\} + n\Psi > 0. \qquad \text{(A19)}$$

■

A.3 Proof of Result 3

Proof. As discussed in the main text, an equilibrium with positive profits only exists under efficiency wages if (and only if), under such a scheme, they are positive for $n = \tilde{n}$. By substituting for (13) in (14), and defining with $\tilde{\alpha}$ the corresponding wage rent term, we get:

$$\sum \pi_{EW}|_{n=\tilde{n}} = \tilde{n}\left\{\frac{a^2}{\left[\frac{a}{\sqrt{cv\left(\frac{r+z}{z}\right)}}\right]^2 c} - v\tilde{\alpha})\right\}. \qquad \text{(A20)}$$

Using some algebra, (A20) becomes:

$$\sum \pi_{EW}|_{n=\tilde{n}} = \tilde{n}v\left(\frac{r+z}{z} - \tilde{\alpha}\right) \tag{A21}$$

which is strictly positive for:

$$z < \frac{r}{\tilde{\alpha}-1}. \tag{A22}$$

■

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