ON THE RELATIONSHIP BETWEEN WAGES AND MONITORING IN SHIRKING MODELS

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ABSTRACT

In shirking models of efficiency wages a higher monitoring intensity is often argued to allow for a reduction in the wage. This paper shows that the relationship between wages and monitoring intensity can be positive within a single firm, especially if the monitoring intensity is determined optimally. Moreover, given alternative firm objectives, a positive relationship can also exist across firms. Thus, shirking models do not generate a unique association between wages and monitoring intensity and empirical evidence on their correlation can only provide information on the relevance of shirking models under restrictive assumptions.

1. INTRODUCTION

Efficiency wage models represent a theoretically convincing explanation of the wage determination process since they can rationalize wages in excess of the market clearing level as the outcome of individually optimal behaviour. However, the empirical support for these models is not overwhelming. This is especially true for shirking approaches. One possible empirical test of shirking models consists of an analysis of the relationship between wages and the strictness with which workers are monitored. This test is based on the hypothesis that a better control of work performance reduces the necessity to pay high wages. The traditional point of view, therefore, posits a negative correlation between monitoring intensity and wages in shirking models, as the subsequent citations illustrate:

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Supervisor intensity and wage bonuses are substitutes... (Leonard (1987, p. S142))

The shirking version... predicts a negative relationship [between supervision intensity and wages] when workers of equal ability in similar jobs are being compared (Kruse (1992, p. 239))

Research... has shown that wages fall when supervision is high [and that this] relationship is consistent with the efficiency wage hypothesis through the argument that there is less need to pay efficiency wages to reduce shirking when supervision is high (Green and McIntosh (1998, p. 366))

The shirking version of efficiency wages claims that the firm can obtain a given level of effort either by paying higher wages with lower monitoring or by engaging in tighter monitoring with lower wages (Chang and Lai (1999, p. 298))

The shirking theory predicts that workers need less supervision if their pay is high relative to other firms’ pay for the same type of work (Bewley (1999, p. 126))

The empirical evidence on this aspect of the shirking model of efficiency wages is summarized succinctly by Bewley (1999, p. 126) in his recent monograph:


This paper shows that a positive relationship between monitoring intensity and wages can be consistent with a shirking model of efficiency

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1 Further works in which the relationship between monitoring and wages is employed as a test of the shirking model include Capelli and Chauvin (1991) and Ewing and Payne (1999). It should be noted that a negative association between wages and the monitoring intensity is not an exclusive feature of efficiency wage models. In team production problems also, for example, wages decrease with monitoring (cf. Alchian and Demsetz (1972)). Thus, the link between wages and monitoring does not necessarily allow for a distinction between different wage determination mechanisms.
wages. In particular, such a correlation will be feasible if the monitoring intensity is determined endogenously. Moreover, wages and monitoring intensity can be correlated positively across firms for companies with differential objectives, even if there is a negative relationship within each individual firm. Thus, empirical studies which find no relationship between wages and monitoring intensity—or a positive association—do not necessarily constitute a refutation of the shirking model of efficiency wages.

The next section derives the traditionally purported view of the relation between wages and monitoring in a simple efficiency wage model with an exogenous monitoring intensity. It is shown that the negative correlation between wages and monitoring intensity only holds under simplifying assumptions. Subsequently, the profit-maximizing firm is allowed to select the monitoring intensity optimally. The conditions are established under which an inverse relationship between wages and monitoring intensity exists and the related literature is discussed. Section 3 looks at differences in the relation between wages and monitoring intensity across firms. In order to focus on this issue, a negative relationship between wages and monitoring intensity within a single firm is assumed. It is shown that a firm which maximizes a weighted sum of profits and an employment objective selects lower wages and less monitoring than a profit-maximizing firm. Section 4 summarizes the findings.

2. A PROFIT-MAXIMIZING FIRM

2.1 The ‘traditional’ view

The label ‘traditional’ view refers to an interpretation of shirking models of efficiency wages as outlined in section 1. According to this view, as exemplified by the Shapiro–Stiglitz (1984) model, a given level of effort requires a higher wage payment, the lower the monitoring intensity or the probability of detecting a shirker is, and vice versa. Often in these approaches, an exogenously given monitoring intensity is assumed. In order to replicate this view and point out the underlying assumptions, the formal analysis is confined to a single firm which, initially, is assumed to maximize profits. There are $n$ employees; their wage is denoted by $w$, and $\gamma$ depicts unit monitoring costs. Let a unit of monitoring or the monitoring intensity be denoted by $s$, such that total monitoring input is given by $S = sn$ and aggregate monitoring costs are $\gamma S$. Since total monitoring costs are linear in employment “diseconomies
of scale in monitoring workers” (Boal and Ransom (1997, p. 95)) are disregarded. For a given output price normalized to unity and a strictly concave production function \( f \) with efficiency units of labour \((en)\) as its argument \((f''(en) > 0, f'' < 0, f(0) = 0)\), where \( e \) depicts the effort or productivity of employees, profits \( \Pi \) are defined by

\[
\Pi = f(en) - wn - \gamma S
\]  

Let effort \( e \) be a function of wages \( w \) and of the monitoring intensity \( s \). The effort function is strictly concave in each of its arguments, implying \( e_w, e_s > 0, e_{ww}, e_{ss} < 0 \). For an exogenously determined level of monitoring, the first-order conditions for the firm’s profit maximization exercise are

\[
\Pi_w = f'e_w - 1 = 0 \quad (2)
\]
\[
\Pi_n = f'e - (w + \gamma s) = 0 \quad (3)
\]

Higher effort is assumed to increase employment for a given wage, such that \( \partial n/\partial e > 0 \) holds, implying \( f''en + f' > 0 \). The change in wages \( w \) due to a rise in the monitoring intensity \( s \) is

\[
\frac{dw}{ds} = -\frac{e_w(w + \gamma s) + e_w\gamma - e_s}{e_{ww}(w + \gamma s)} \quad (4)
\]

Since the monitoring intensity \( s \)—or the detection probability—is exogenous, monitoring costs \( \gamma \) are often ignored and set equal to zero (cf. Shapiro and Stiglitz (1984) or Leonard (1987)). If, in addition, the cross-derivative of the effort function \( e_{ws} \) is non-positive, which will be the case, for example, if effort is additively separable in wages and monitoring intensity, wages will fall with a rise in the monitoring intensity. Hence, a positive correlation between wages and monitoring intensity has been interpreted as a refutation of the shirking approach. Obviously, this ‘traditional’ view imposes constraints on the effort function which are not necessarily justified by economic theory. Moreover, this interpretation ignores that any means of eliciting higher effort—be it wages or monitoring—is costly. In addition, the monitoring intensity cannot, in general, be regarded as an

\[\text{Footnote 2: The possibility of a negative relationship between effort and monitoring can arise if supervision is an adverse characteristic of a job. In this case, monitoring requires compensating wage differentials (Groshen and Krueger (1990), Kruse (1992)). However, this problem can be neglected since the focus is on the relationship between wages and monitoring given efficiency wages.}\]
exogenous variable which is institutionally fixed. Instead, the level of the monitoring input represents a choice variable for the firm. This will be an especially relevant objection to the ‘traditional’ view if the monitoring intensity is interpreted as the supervisor to staff ratio, since firms are usually not restricted in their choice of the number of supervisors.³

2.2 Endogenizing the monitoring intensity

The above argument suggests that in order to evaluate the relationship between wages and monitoring intensity the endogeneity of the latter has to be taken into account. Accordingly, the firm is presumed to maximize profits with respect to wages \( w \), employment \( n \) and the monitoring intensity \( s \). The first-order conditions for the maximization problem are given by equations (2), (3) and (4)

\[
\Pi_s = f'e_s - \gamma = 0 \tag{5}
\]

The combination of (2) and (3) yields a Solow-type condition (Solow (1979)) while (3) and (5) give rise to a similar condition for the monitoring intensity and employment.

\[
e_w (w + s\gamma) - e = 0 \tag{6}
\]

\[
e_s (w + s\gamma) - e\gamma = 0 \tag{7}
\]

From (6) note that \( e_w w/e = 1 - e_w s\gamma/e < 1 \). The combination of (2) and (5) shows that \( e_w = e_s \) at the firm’s optimum (cf. Bowles (1985)) and (7) implies \( e_s s - e < 0 \). Since wages and monitoring intensity are determined endogenously, a correlation between the two arguments of the effort function can be established by altering an exogenous variable, such as the price \( \gamma \) per unit of monitoring intensity. Totally differentiating the equilibrium conditions (3), (6) and (7) and making use of the above relationships for the effort function yields

³ The supervision to staff ratio, or related measures, has been employed as an indicator of the monitoring intensity by Leonard (1987), Groshen and Krueger (1990), Brunello (1995) and Ewing and Payne (1999), inter alia. Groshen and Krueger (1990) argue that in some professions minimum supervisor to staff ratios exist. If these minimum ratios exceed the profit-maximizing relation, the monitoring intensity will obviously be fixed.

⁴ Bowles (1985) and Chang and Lai (1999) also analyse such a problem. However, these authors do not explore the implications of an endogenous choice of the monitoring intensity and its correlation with wages.

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\[
\frac{dW}{dy} = - \frac{e_w s e_{ss} - e_w s (e_s s - e)}{(w + sy) A}
\]  
(8)

\[
\frac{ds}{dy} = - \frac{e_w s (e_s s - e) - e_w s e_{ws}}{A}
\]  
(9)

where \( A \equiv e_w s e_{ss} - e_w^2 > 0 \) if the second-order sufficiency requirement is fulfilled. Since the sign of \( e_{ws} \) is yet undetermined, a rise in unit monitoring costs \( \gamma \) has uncertain consequences on the monitoring intensity \( s \) and the wage \( w \). The intuition for the ambiguity is that, on the one hand, a fall in the monitoring intensity \( s \) might reduce marginal effort \( e_w \). If this is the case, there will be an incentive for the firm to lower the wage since the additional effort owing to higher wages is less than before the reduction in \( s \). On the other hand, the cost or substitution effect implies a negative relationship between the monitoring intensity \( s \) and wages \( w \) since the firm uses more of the relatively cheaper device for increasing effort, that being wages subsequent to the rise in unit monitoring costs. Without specifying the effort function in more detail, it cannot be ascertained which of the two effects dominates.

If, for example, the effort function is of a Cobb–Douglas-type, \( e_{ws} > 0 \) will hold. Moreover, for \( e = w^\alpha s^\beta + c \), \( 0 < \alpha, \beta, c \), and \( \alpha + \beta < 1 \), \( dw/d\gamma < 0 \) and \( ds/d\gamma < 0 \) apply. For such an effort function, wages and monitoring intensity are positively related.\(^5\) If, however, effort is an increasing and additively separable function of wages and monitoring intensity, as often assumed, a rise in unit monitoring costs \( \gamma \) will lower the monitoring intensity \( s \) and drive up the wage. This implies a negative relationship between the monitoring intensity and the efficiency wage. More generally, \( e_{ws} \leq 0 \) is a sufficient condition for \( dw/d\gamma > 0 \) and \( ds/d\gamma < 0 \) to hold.\(^6\)

The necessity to know the specification of the effort function in order to use empirical findings on the relationship between wages and monitoring as evidence with respect to the relevance of shirking models will become more obvious if the findings of other theoretical studies are taken into account. Schmidt-Sørensen (1990, pp. 595f.) presumes “that the degree of

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\(^5\) The formal derivation can be found in the appendix. The relevance of an endogenous determination of the monitoring intensity for empirical work has been recognized by Groshen and Krueger (1990) and Brunello (1995), \textit{inter alia}. The implications of the endogeneity of monitoring for an assessment of efficiency wage models are not explored in these papers.

\(^6\) In developing his empirical specification, Leonard (1987) actually makes the assumption \( e_{ws} < 0 \) without, however, indicating its importance. Hence, Gordon (1990, p. 30) is correct in claiming that in “many efficiency wage models, the cross partial is normally postulated to be negative”.

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imperfect monitoring may be considered to be a function of the firm size as measured by the number of workers” and therefore specifies effort as $e = e(w, n, s)$, where the cross-derivatives are assumed to be zero implying $e_{ws} = 0$, in particular. Schmidt-Sørensen (1990, pp. 598f.) then proceeds to show that “a trade-off between wages of workers and number of supervisors only appears certain if ... $(e_{nn})$ is negative”. Moreover, Arai (1989) has demonstrated that, if employees do not exactly know the effort standard which is set by the firm, more intensive monitoring might increase the employees’ information and decrease the level of effort, such that effort and monitoring can be negatively related. If such uncertainty is an important determinant of effort, the relationship between wages and monitoring intensity will be ambiguous. Finally, Brunello (1992) has argued that even for an exogenous probability of being caught shirking, the monitoring intensity and the wage might be positively correlated if an additional reward for not shirking is the promotion to a supervisor’s job.

Equations (8) and (9) show that wages and monitoring intensity might be correlated either positively or negatively in a shirking model of efficiency wages. This result is strengthened by the findings for an alternative effort function by Schmidt-Sørensen (1990) and extensions of the basic shirking model by Arai (1989) and Brunello (1992). The correlation between monitoring or supervision intensity and wages does not allow for statements about the validity of shirking models of efficiency wages in profit-maximizing firms, since any kind of correlation is compatible with the approach. Instead, a statement about the correlation between wages and monitoring intensity within a firm requires detailed knowledge of the effort function. The next section shows that, even if the effort function warrants the prediction of a negative relation between wages and monitoring intensity within a single firm, this correlation will not have to hold across firms if companies do not solely maximize profits. Hence, the knowledge of the characteristics of the effort function might not suffice to evaluate shirking models on the basis of empirical evidence about the link between wages and monitoring.

3. ALTERNATIVE FIRM OBJECTIVE

3.1 Effort function

In order to simplify the subsequent calculations, a specific effort function is presumed which warrants $e_{ws} = 0$. This assumption can ensure that the relationship between wages and monitoring intensity is negative.
within the firm. Thus, it is possible to focus attention on the consequences of alternative firm objectives. The specific effort function is based on a static framework by Pisauro (1991). In this setting it is assumed that an employed worker can either provide the required level of effort throughout the exogenously fixed number of working hours or that s/he might shirk for a fraction of working time. Thus, effort $e$ is given a temporal interpretation (cf. also Bowles (1985)). If the worker shirks, s/he will be detected with a probability $p$ and fired. In the framework by Pisauro (1991) individual utility $\mu$ is additively separable in the (indirect) utility $v$ from income $y$ and effort $e$ and can be depicted as

$$\mu = v(y) - e$$  \hspace{1cm} (10)$$

The sub-utility function $v$ is strictly concave in income ($v' > 0$, $v'' < 0$, $v(0) = 0$). Normalizing total working time to unity, $e = 1$ implies no shirking. All employees in the company are identical ex ante and paid a wage $w$. If an employee loses his or her job, s/he will find another one with probability $1 - u$ and remain unemployed with the opposite probability $u$. The probability $u$ can be interpreted as unemployment rate. If the employee finds a new job, s/he will exert an effort level $e^a$ and be paid a wage $w^a$. The alternative wage $w^a$ and the effort level $e^a$ are exogenous from the point of view of the company under consideration. If the employee does not find another job, no effort will be required and income will amount to $b$. For simplicity, there is no discounting. Hence, the expected utility $E(U)$ of a representative employee who might be shirking is defined by

$$E(U) = [v(w) - e](1 - p) + [v(w^a) - e^a]p(1 - u) + v(b)pu$$  \hspace{1cm} (11)$$

where $v(w^a) - e^a - v(b) > 0$ holds to satisfy the participation constraint. Moreover, the optimal wage–effort combination is presumed to entail no incentives for employees to leave the firm. Finally, let $p$ be a constant proportion of the time during which an employee is not exerting effort, where this fraction is determined by the monitoring intensity $s$, such that $p = s(1 - e)$. Replacing $p$ and maximizing $E(U)$ with respect to $e$ yields the optimal level of effort $e$ of a representative employee, given the wage offered by the company—or his or her effort function.

$$e = \frac{1}{2} \left[ v(w) - \frac{1 - s}{s} - \kappa \right]$$
where
\[ \kappa \equiv [\nu(w^a) - e^a](1 - u) + \nu(b)u \]  

(12)

Optimal effort \( e \) is assumed to be bounded by zero from below and by one from above. The effort function is strictly concave in the wage \( w \) and the monitoring intensity \( s \) \( (e_s = 1/2s^2 > 0, \quad e_{ss} = -1/s^3 < 0) \), while the cross-derivative is zero \( (e_{ws} = 0) \). Furthermore, effort as defined by equation (12) rises with the unemployment rate \( u \). The effort function is thus consistent with dynamic specifications of the shirking problem, such as those by Shapiro and Stiglitz (1984) or Rasmussen (1998). Accordingly, the simplification owing to the static approach and due to the assumption of additive separability of effort with respect to \( w, s \) and \( \kappa \) does not affect the qualitative features of the shirking problem.

### 3.2 A firm with an employment objective

A profit-maximizing firm is the natural starting point for an investigation of the relationship between wages and monitoring intensity. However, firms often have other objectives besides profit maximization. Firms might be interested in reaching or sustaining a certain market share, obtaining a specific share price, providing their employees with job security or having a high level of employment. The latter objective is especially relevant in, for example, companies in which the board of directors also includes worker representatives, as in industrial relation systems characterized by co-determination rules. Assume, therefore, that the firm under consideration also has an employment objective. Such a firm can be shown to choose a lower wage and a lower monitoring intensity than a profit-maximizing company does. Therefore, if the objectives of firms are not exactly known to the empirical researcher, s/he might wrongly deny the relevance of shirking models if no inverse relationship between monitoring intensity and efficiency wages is found across firms. In order to demonstrate this result, suppose the firm maximizes the objective \( Z \)

\[ Z = \Pi + \alpha X(n) \]  

(13)

The function \( X \) is increasing with employment \( n \) at a non-increasing rate \( (X' > 0, \quad X'' \leq 0) \). The parameter \( \alpha > 0 \) indicates the importance of the secondary employment objective relative to the profit motif. If employ-
ment has a greater weight in the firm’s objective than profits have, then $$\alpha > 1$$ will hold. The first-order conditions of the firm’s maximization problem are given by equations (2), (5) and (14) while the combination of (2) and (5) yields (15)

$$Z_n = f'e - w + \alpha X' - y s = 0$$ (14)
$$e_w y - e_s = 0$$ (15)

The system of the three equations (15), (2) and (14) can be totally differentiated, where use has been made of the effort function (12) and its properties, namely $$e_{ws} = 0$$.

$$\begin{bmatrix} e_{ww} y \\ f''n + f'e_{ww} \\ f''e_{en} \\ f''f' + e^2 + \alpha X'' \\ f''f'e_{es} \end{bmatrix} \begin{bmatrix} dw \\ dn \\ ds \end{bmatrix} = \begin{bmatrix} 0 & -e_w \\ 0 & 0 \\ -X' & s \end{bmatrix} \begin{bmatrix} d\alpha \\ dy \end{bmatrix}$$ (16)

The determinant $$D$$ of the system is positive as $$X'' \leq 0$$, $$e_{ss}$$, $$e_{ww}$$, $$f'' < 0$$ hold, and is given by

$$D = -e_{ww} y \alpha X'' f'' f' e_{w} e_{s}$$

$$- e_{ss}[f''(e_w)^2 \alpha X'' n + f'e_{ww}(f'' e^2 + \alpha X'')] > 0$$ (17)

A greater importance of the employment objective implies a higher value of $$\alpha$$ and reduces the wage $$w$$ and the monitoring intensity $$s$$, while employment $$n$$ rises.

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7 Given profitable firms, an alternative justification for the employment objective might be the ‘expense preference theory’. The objective function (13) conforms most closely to the third of the specifications distinguished by Rees (1974, p. 298), in that “the firm chooses a higher ratio of staff to other inputs than is implied by cost minimization; however, the firm is on the boundary of its production set”. A further interpretation of (13) is that a firm maximizes profits and faces labour costs which are non-linear in wages (for $$X'' > 0$$) or include fixed employment costs ($$X'' = 0$$). I owe the latter point to Winfried Pohlmeier. However, the assumption that the technology is the same for all companies, irrespective of their ownership status, still implies that $$\alpha$$ is larger for those companies with an employment objective.
Higher employment raises the firm’s costs and reduces its profits. In order to counteract this reduction in profits, the firm saves on other costs, i.e. wages and monitoring expenses. Since unit monitoring costs are given, the firm lowers the monitoring intensity accordingly.\(^8\)

Moreover, a rise in the costs \(\gamma\) per unit \(s\) of monitoring intensity will raise wages, lower employment and reduce the monitoring intensity if \(w > \alpha X'\) holds.

\[
\frac{dw}{d\gamma} = \frac{e_{ss} X' f''e e_w}{D} < 0
\] (18)

\[
\frac{ds}{d\alpha} = -\frac{e_{ww} \gamma f''e e_w X'}{D} < 0
\] (19)

\[
\frac{dn}{d\alpha} = -\frac{e_{ww} \gamma f''n e_w + e_{ss} (f''e_{en}^2 n + f''e_{ww} n)}{D} X' > 0
\] (20)

Since \(f' e - \gamma s = w - \alpha X'\) in accordance with the first-order condition (14), the wage must exceed the marginal employment effect \(\alpha X'\) for an increase in unit monitoring costs \(\gamma\) to lower the monitoring intensity unambiguously. The employment effect is determined by

\[
\frac{dn}{d\gamma} = \frac{e_{ww} f''e_w e_s n (f' e - \gamma s) - se_{ss} (f''e_{ww} + f''e_{ww}^2 n)}{D}
\] (23)

Partly substituting according to equation (2) and employing \(e_s = 1/2s^2\) and \(e_{ss} = -1/s^3\), the expression in equation (23) can be simplified to

\[
\frac{dn}{d\gamma} = \frac{e_{ww} (f''e n + 2f')}{{2D}s^2} - \frac{(e_w e_s' + e_{ww} e_{ss} f''e_{ww} n)}{D} < 0
\] (24)

for \(f''e n + f' > 0\). Given \(w > \alpha X'\), wages and monitoring intensity will move in opposite directions in a firm with an employment objective if

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\(^8\) If the monitoring intensity \(s\) is given exogenously, an increase in \(\alpha\) will reduce wages and raise employment (Goerke (1998)).
unit monitoring costs $\gamma$ rise. Thus, the inverse correlation between wages and monitoring intensity within the firm can continue to exist.

Suppose a researcher observes two firms which are characterized by the same technical parameters and would thus pay the same wage and choose the same monitoring intensity if they had the same objectives. However, firm A maximizes profits while firm B maximizes a weighted sum of profits and an employment objective. According to equations (18) and (19), wages and monitoring intensity are higher in firm A than in firm B. In the absence of information about the exact objectives of the firms—and the level of effort—the researcher observes a positive correlation between wages and monitoring intensity across firms. At first sight these observations refute one of the central claims of the shirking models of efficiency wage theories. However, a positive correlation between wages and monitoring intensity across firms is perfectly consistent with a shirking model of efficiency wages. Accordingly, care has to be exercised to control for the firms’ objectives. Alternatively, it has to be ensured that the objectives are the same, as presumably will be the case if different plants of a single firm are considered (cf. Capelli and Chauvin (1991)).

4. SUMMARY

It is often asserted for shirking models of efficiency wages that a higher level of supervision reduces wages. In empirical work, the existence (absence) of such an inverse relationship between monitoring or supervision and the level of wages has been interpreted as being consistent with (a refutation of) a shirking-based explanation of unemployment. It has been shown that the proclaimed inverse relationship will only unambiguously exist at the firm level if the effort function has a specific form. More precisely, a sufficient condition for the inverse relationship between wages and monitoring intensity in a setting in which a profit-maximizing firm chooses wages, monitoring intensity and employment optimally is that the gain in effort owing to a higher wage must not increase with the monitoring intensity, assuming an effort level which is independent of the number of employees. However, in general, any kind of relationship between wages and monitoring intensity is consistent with a shirking model of efficiency wages. In addition, even if there is an inverse relationship between wages and monitoring within a single firm, its existence across otherwise identical firms can depend on the firms’ objectives. It has been shown that a firm characterized by an objective
function which consists of a weighted sum of profits and employment pays lower wages and monitors less intensively than a profit-maximizing company.

Empirical tests of the shirking model of efficiency wages cannot solely rely on information about the correlation between wages and monitoring intensity either within or across firms. Economic theory cannot make unambiguous statements about this link, unless the effort function and the firm objective are specified in detail. Evidence on the correlation between wages and monitoring intensity is unlikely to yield substantial insights about the relevance of the shirking model of efficiency wages. Thus, empirical tests of this approach might rather investigate the link between the efficiency wage and the unemployment rate (the alternative income)—although the hypothesized negative (positive) correlation can be consistent with various labour market models. The shirking model of efficiency wages might not have fared well empirically thus far. In this paper it has been argued that the shirking model cannot be rejected on the basis of a positive correlation between the wage level and the monitoring intensity unless detailed information on the characteristics of the effort function and the firms’ objectives are available.

APPENDIX: EXAMPLE OF A POSITIVE CORRELATION BETWEEN WAGES AND MONITORING INTENSITY

Suppose effort is defined by a Cobb–Douglas-type function plus a constant $c$.

$$e = w^\alpha s^\beta + c$$  \hspace{1cm} (A1)

where $c$ is small but positive ($c > 0$) and the parameters $\alpha$, $\beta$ are also greater than zero but less than unity ($0 < \alpha, \beta < 1$). The derivatives of the effort function with respect to wages $w$ and the monitoring intensity $s$ are

$$e_w = \alpha w^{\alpha - 1}s^\beta > 0$$  \hspace{1cm} (A2)

$$e_s = \beta w^\alpha s^{\beta - 1} > 0$$  \hspace{1cm} (A3)

$$e_{ww} = \alpha (\alpha - 1)w^{\alpha - 2}s^\beta < 0$$  \hspace{1cm} (A4)

$$e_{ss} = \beta (\beta - 1)w^\alpha s^{\beta - 2} < 0$$  \hspace{1cm} (A5)
The determinant \( A \) of the system which consists of equations (3), (6), and (7) is positive for \( \alpha + \beta < 1 \). This restriction is imposed henceforth:

\[
A = e_{ws}e_{ss} - (e_{ws})^2 = a\beta w^{2(\alpha - 1)}s^{2(\beta - 1)}(1 - \alpha - \beta) > 0 \tag{A7}
\]

The changes in the wage and monitoring intensity due to a rise in unit monitoring costs \( \gamma \) are given by equations (8) and (9). Using (A1)–(A7), these variations can be expressed as

\[
\frac{dw}{d\gamma} = -\frac{ca\beta w^{\alpha-1}s^{\beta-1}}{A(w + s\gamma)} < 0 \tag{A8}
\]

\[
\frac{ds}{d\gamma} = -\frac{aw^{2(\alpha-1)}s^{2\beta}(1 - \alpha - \beta) + c(1 - \alpha)w^{\alpha-2}s^\beta}{A} < 0 \tag{A9}
\]

Given the effort function as specified in (A1), wages and monitoring intensity will move in the same direction if unit monitoring costs rise.

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