

Estimating the Shirking Model with Variable Effort

Eric STROBL¹ and Frank WALSH²

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Abstract

We show in a theoretical efficiency wage model where firms differ in monitoring intensity or in the effort intensity of their technologies that the impact of monitoring intensity on wages is ambiguous, a result that mirrors evidence from the empirical literature. We argue that to correctly specify the impact of monitoring on wages, the interaction between monitoring and effort needs to be modelled. Results using a worker, firm panel from Ghana which contains reasonable effort and monitoring proxies show that the return to effort is higher in poorly monitored sectors as the theory suggests.

Keywords: Efficiency wages, effort, monitoring intensity

JEL classification: J30

¹CORE, Université Catholique de Louvain, Belgium. E-mail: strobl@core.ucl.ac.be

²Department of Economics, University College Dublin, Ireland. E-mail: frank.walsh@ucd.ie.

Section I: Introduction

One of the most influential variants of the efficiency wage models is the shirking model, most notably Shapiro and Stiglitz (1984). Accordingly, firms pay wage premiums to ensure workers do not have the incentive to engage in costly shirking. In terms of establishing an empirical relationship between wages and supervision this framework has, however, produced mixed results and at best predicts small wage differentials. This is not that surprising given that in more recent efficiency wage models where effort is allowed to vary [Walsh (1999) or Goerke (2001)], increased supervision has an ambiguous effect on wages.

In the current paper we generalise the Walsh (1999) model in a simple way in order to illustrate that if some firms use a technology that is more effort intensive than others, the model can predict large wage differentials across similar workers. We subsequently use an employer-employee matched data set for Ghana that allows us to explicitly model the impact of the interaction between monitoring intensity and the effort level on wages. Moreover, while the previous literature has either estimated the impact of supervision with the level of effort fixed or the impact of effort on wages using various proxies for effort, our dataset has reasonable proxies for both effort and supervision. In addition we can instrument for effort, which is arguably endogenous, using a measure of temporary demand shocks to the firm. Our results show that the coefficients on monitoring, effort, and on the interaction between them are precisely estimated and that the signs are in line with theory.

This paper is organised as follows. In the following section we outline our theoretical model. Section III surveys the empirical literature on the impact of supervision and effort on wages. Our data set is described in Section IV. Empirical results of our econometric investigation are contained in Section V. The final section provides concluding remarks.

Section II: The Theoretical Model

First we summarise the relationship between wage and effort derived in Walsh's (1999) multi-sector version of the Shapiro and Stiglitz (1986) model. Accordingly, workers are assumed to be identical and live forever and have the following instantaneous utility function:

$$u = w - g(x) \quad (1)$$

where utility is u , w is the real wage, x is effort, and $g(x)$ is a convex function. An employed worker caught shirking is fired instantaneously and receives a benefit B . The flow value of a job in sector i for shirkers s and non-shirkers n , respectively, at any point in time (t) are:

$$\begin{aligned} rV_i^s(t) &= w_i + (b + q_i)[V_u(t) - V_i^s(t)] + \dot{V}_i^s(t) \\ rV_i^n(t) &= w_i - g(x_i) + b[V_u(t) - V_i^n(t)] + \dot{V}_i^n(t) \end{aligned} \quad (2)$$

The Poisson arrival rate of exogenous job separations and supervisors are b and q_i , respectively, and the discount rate is r . In equilibrium these two arrival rates will have opposite but symmetric effects on the firms no-shirking condition. Since it will not feature in our empirical specification we assume that the separation rate is constant across sectors. Moreover, we focus on a stationary equilibrium.

The firm will pay a wage such that the value of not shirking is as good as shirking. Equating (1) and (2) and defining V_u as the flow value of unemployment, gives the following equation for rents in any sector:

$$V_i(t) - V^u(t) = \frac{g(x_i)}{q_i} \quad (3)$$

This equation is important as it shows that rents are proportional to the disutility of effort and monitoring intensity. For a given monitoring intensity, if a firm chooses

higher effort the wage that satisfies the no-shirking condition will not just give the worker a compensating wage increase, but will also give the worker higher rents. The flow value of unemployment is:

$$rV^u(t) = B + \sum a_j[V_j(t) - V^u(t)] + \dot{V}^u(t) \quad (4)$$

The acquisition rate into employment in any sector j from unemployment is a_j . One can use the above equations to solve for the wage that satisfies the no-shirking condition ($V_i^n = V_i^s$):

$$w_i = g(x_i)D_i + c \quad (5)$$

where $D_i = (1 + \frac{b+r}{q_i})$ and $c = B + \sum_{j=1}^n a_j [\frac{g(x_j)}{q_j}]$. Both D_i and c are exogenous to the

firm and c is constant across sectors representing the value of re-employment opportunities that are available in unemployment. Equation (5) (the effort supply curve) is graphed in Figure 1 for two firms with different monitoring intensities. The firm with higher effort (Effort 2) at any given wage has more intensive monitoring. Next we turn to the firms profit maximisation problem. In terms of Figure 1, since monitoring is exogenous, the firm takes the effort supply curve as given. The firm in sector i will choose a combination of wage and effort along the effort supply curve to maximise profits.

The profit maximisation problem for a firm in sector i is:

$$\text{Max}_{w_i, l_i} \pi = p_i f[z_i(w_i)^{A_i} l_i^{B_i}] - w_i l_i \quad (6)$$

We denote effort by z rather than x here for reasons discussed below. This formulation replaces the Solow (1979) model where efficiency units of labour are produced using a Cobb-Douglas function where effort and employment have the same weight in production: $f[x(w), l] = f[x(w)l]$, with a Cobb-Douglas formulation where the weights

on effort and wages (A,B) are allowed to be different. This generalisation is the key difference between the model in Walsh (1999).

We see that by replacing z in (6) with the transformation $z_i = x_i^{\frac{A_i}{B_i}}$ one gets the Solow model. As long as $g_z(z) > 0$ and $g_{zz}(z) < 0$ the second order conditions from the profit maximisation problem in (6) are satisfied. This transformation illustrates that in a one sector model allowing effort and employment to have different weights is a trivial generalisation. It is only when one looks at differences across firms that it may be important. We will assume that sector k is the least effort intensive sector, so that when we impose the transformation $z_i = x_i^{\frac{A_i}{B_i}}$ then $A_k = B_k$, but for any other sector j $A_j > B_j$.

Our more general formulation addresses the objections to the Solow model outlined in Akerlof and Yellen (1986) p14. Akerlof and Yellen argue that an elasticity of effort with respect to the wage of unity, which the Solow model yields, is quite high and that if this elasticity never is that high, then there cannot be an equilibrium with unemployment. They argue that if a reduction of worker effort leads to damage to other factors or lost opportunities to the firm, the elasticity would be lower than unity³. Ramana and Rowthorn (1991) also discuss Akerlof and Yellen's concerns in terms of the ease of substitution between effort and hours. They give examples of assembly line workers or airline pilots where negligence by one worker may cause a great deal of damage either to the firms capital or to other workers output. While it is true that the ease of substitution between hours and effort will be low in such cases, it is also true that the amount of effort that is combined with hours to produce output will vary across

³ Faria (2000) develops a model with turnover costs, supervision and managerial control where the Solow model will not hold in many circumstances.

sectors as a result. The model below seeks to capture the latter feature. Generalising the elasticity of substitution is ignored in the interests of tractability.

The profit maximising choice of w and n implies:⁴

$$x_{iw_i} \frac{w_i}{x_i} = \frac{B_i}{A_i} \quad (7)$$

In this model the elasticity of effort may be less than unity and the model is consistent with unemployment addressing Akerlof and Yellens concern, although Walsh (1999) shows that the model is also consistent with full employment if there is a sector with perfect monitoring to clear the market. Using (5) the wage from the effort supply curve and imposing the condition from (7) on this we can solve for the following equation:

$$\frac{c}{D_i} = \frac{B_i}{A_i} g_x(x_i)x_i - g(x_i) \quad (8)$$

By differentiating both sides of (8) we see that for a given effort intensity, a sufficient condition for an increase in monitoring intensity to lead to an increase in effort is that

$\frac{B_i}{A_i} \leq 1$ which will be true in each sector. It also follows that the wage is:

$$w_i = \frac{c}{1 - \frac{1}{\varepsilon_{g(x_i)}} \frac{A_i}{B_i}} \quad (9)$$

Where $\varepsilon_{g(x_i)}$ is the elasticity of the disutility of effort with respect to effort in sector i .

This depends on the workers' preferences. Whether this elasticity is increasing or decreasing in effort determines whether the wage will increase or decrease with monitoring intensity. Walsh (1999) gives examples where the elasticity is constant, increasing or decreasing as monitoring intensifies (the separation rate falls). From (9) we could simulate wage differentials where small differences in the effort intensity or the

⁴ Walsh (2001) looks at a simple macroeconomic model where the elasticity of substitution between effort and workers can vary.

elasticity of the disutility of effort with respect to effort can predict large wage differentials across firms for identical workers. In terms of Figure 1 a firm with a more intensive technology (higher A/B) would choose a higher wage effort combination on its effort supply curve (point 2 as against point 1). For a given effort intensity a firm with more intensive monitoring would move onto a higher effort supply curve, but as we saw in (8) would substitute away from effort. Whether this substitution effect would be large enough to reduce wages depends on the shape of the effort supply curve (whether the elasticity in (9) is increasing or decreasing).

While the above discussion shows that the impact of supervision on wages is ambiguous, it is clear that to correctly estimate the relationship we must take account of changes in effort. It is also clear that since a change in supervision changes the firm's wage effort combination, effort is endogenous.

Section III: The Empirical Literature on Supervision, Effort and Wages

One can see from equation (5) that for a given effort level the model predicts that wages will be higher for a lower supervision rate. In other words, in the model outlined above, in a given firm the wage will increase more as effort increases the lower the supervision rate is. Strobl and Walsh (2002) incorporate effort into a monopsony model of the labour market and show that firms with monopsony power will pay lower wages but demand higher effort levels. In contrast, competitive labour market theory also predicts that higher effort would be compensated with higher wages but there would be no relationship between the effort level and monitoring intensity. In terms of Figure 1 the competitive model predicts that movements along an effort supply curve would reflect compensating differentials for higher effort and all firms would have the same

effort supply curve since monitoring would not affect wages.⁵ In summary, different economic models can predict either a positive or negative relationship between effort and wages across firms, but only the efficiency wage model predicts that the supervision level will be an important determinant of the relationship between effort and wages. The efficiency wage model does not necessarily predict that sectors with low supervision will have high wages, since as we saw earlier such a firm may pay the same wage but lower the effort level. The model does, however, predict that firms where it is difficult to supervise will pay higher wages per unit of effort.

In terms of the empirical literature on supervision and wages, there have been mixed results; see Bewley (1999), Goerke (2001), or Walsh (1999) for discussions of these. Different studies find both positive and negative effects of supervision on wages and these effects are typically small. The earlier efficiency wage empirical literature tended to rely on less direct evidence for the efficiency wage hypothesis. For example, Cappelli and Chauvin (1991) looked at wage premiums and discipline for workers in a company with many plants, while Krueger (1991) found higher wages in franchised as against owner run fast food outlets (where supervision is taken to be greater in the owner run outlet). While later studies used more direct measures, the results continued to be mixed. Johannsen and Palme (1996) find that while there is a relationship between economic incentives and effort (measured as absenteeism) an increase in monitoring reduces effort, and they discuss some measurement problems that may explain this. Goldsmith et al (2000) use locus of control (a measure of motivation used by psychologists) as a measure of effort and find a significant relationship between wages and effort using two stage least squares to estimate a separate effort equation. The measures of supervision are establishment size and the number of locations the firm has.

⁵ Black and Garen (1991) also point out that large wage differentials may reflect equalising differentials for different effort rather than efficiency wage payments.

These do not enter the effort equation significantly, but establishment size may act as a proxy for a number of factors other than supervision.

In light of these inconclusive empirical findings, we would argue that the failure to control for effort and the interaction between effort and supervision intensity may be an important omission. Additionally the lack of reasonable proxies for effort used in the past may have played an important role in being unable to find sufficient support for the efficiency wage hypothesis. The current paper not only addresses the issue of allowing for an interaction effect between monitoring and effort, but also is able to use an arguably superior proxy of effort relative to most previous studies. Moreover, we can take advantage of a convincing instrument for effort, which, as was seen in the theoretical section, is likely to be endogenous.

Section IV. Data and Summary Statistics

In this paper we attempt to directly test the shirking efficiency wage model outlined above using data from a panel of workers and firms in the Ghanaian manufacturing sector.⁶ The data used for our empirical analysis are drawn from the *Regional Programme for Enterprise Development* (RPED) dataset for Ghana manufacturing firms collected by the Centre for Studies of African Economies (CSAE) at the University of Oxford. The data that we use here are for the 1998 sample, i.e., the fifth wave.⁷ The initial wave of 200 firms in this survey was drawn from the 1987 Ghana Census of Manufacturing Activities, stratified by size, sector and location.⁸ The sectors from which the firms were chosen are Food, Textiles and Garments, Wood, and Metal, which

⁶ Teal (1996) analyses rents to workers using this dataset. However, in terms of the distinction drawn by Konings and Walsh (1994) between rents from efficiency wages and rents arising from workers extracting a share of imperfectly competitive firm's profits, Teal focuses on the latter source of rents.

⁷ We use this wave rather than, or in addition to, earlier waves given that it is only the latter wave that provides information on the effort level of the worker.

⁸ In the sampling large firms were over-sampled.

together comprise about 70 per cent of total manufacturing employment in Ghana.⁹ When firms were closed down over the period they were replaced with firms in the same size, sector and location category.

The RPED data set is essentially employer-employee matched data in that, while each firm was interviewed for information at the firm level, additionally up to ten of its workers, representative of ten broad occupation categories, were interviewed.¹⁰ Both the firm and worker level data provide us with a rich set of characteristics. Firm level controls used in this paper are employment size, regional location (4 dummies), sector (10 dummies), incidence of state ownership (zero-one type dummy), percentage of union membership, and the percentage of foreign ownership of each firm. We also used detailed information on the breakdown of employment by occupation category at the level of the firm to generate a proxy of monitoring intensity, calculated as the percentage of managers and supervisor employed, MONIT.

Information from the worker surveys allows us to calculate their (logged) hourly wage rate, LOG_WAGE.¹¹ Additionally we included worker level controls for the level of education (years), occupation (19 dummies), tenure (years) and its squared value, age (years) and its squared value, gender (zero-one type dummy), african (zero-one type dummy), marital status (zero-one type dummy), union membership (zero-one type dummy), and permanent worker status (zero-one type dummy).

Most importantly, the RPED data set provides us with a direct measure of the effort level exerted at the worker level. Specifically, the worker is asked “How tired are you at the end of the day?” and has the choice of the following answers: (a) very tired, (b) tired, (c) not really tired, and (d) not tired at all. We use this information to construct a

⁹ In actuality the data set allows us to distinguish among ten sectors within these four main sectors.

¹⁰ For the latter four years firms and workers were interviewed only in the fifth and seventh wave, but information was asked respectively for the two years prior to these dates.

¹¹ One should note that wages are measured as the complete compensation of the individual. In other words, earnings not only include explicit pay, but also the value of other allowances, bonuses and benefits.

measure of effort, EFFORT, a simple zero-one type dummy variable taking on the value of one if answers (a) or (b) were chosen, and zero otherwise. While there are obvious shortcomings in asking a worker if they are tired as a proxy for effort, we feel it is as good or better than those used to date that we are aware of. Secondly, given that we need a proxy for effort in an environment where there is imperfect monitoring, it seems inevitable that we will have to rely on workers to provide the information. If it could be directly observed monitoring would not be imperfect.

The worker is also asked “Is it busy at work at present?”. We interpret this as an indicator of temporary positive shocks on the demand for worker level effort, and created a zero-one type dummy variable, BUSY, to be used as an instrument for effort. We saw in the theoretical section that the supervision variable affects the firm’s choice of both wages and effort. While the BUSY variable would lead to an increase in the demand for effort at the firm, we do not expect the BUSY variable to affect the wage other than through higher effort. This means if we instrument effort with the BUSY variable we can trace out the impact of effort on wages for firms with different levels of supervision.

Overall non-missing observations for all variables left us with a sample of 1,482 non-supervisory, non-managerial workers employed in 154 firms. Summary statistics for our most important variables for these are provided in Table 1. Accordingly, 74 per cent of all workers in our sample are tired at the end of the workday, thus, under our interpretation, exerting high effort. We also find that on average 17 per cent of the workforce is in a managerial or supervisory position, although the standard deviation suggests that this varies considerably across firms. Breaking down our sample into high and low effort workers, the summary statistics suggest that on average high effort workers experience lower earnings and higher monitoring, although the differences are not substantial.

Section V: Empirical Specification and Results

In order to estimate the impact of effort and monitoring intensity of workers' earnings we employ the following standard wage equation:

$$\text{LOG_WAGE} = f(\text{X}, \text{Z}, \text{EFFORT}, \text{MONIT}) \quad (10)$$

where X and Z are vectors of worker and firm level controls, respectively, as outlined above, EFFORT is our measure of effort level exerted, and MONIT is our proxy of monitoring intensity defined above. One can think of (10) as an attempt to estimate the relationship between wages, effort and supervision in equation (5).

We first estimated our wage equation in (10) for the whole sample excluding our effort variable using OLS – the resultant coefficient on MONIT is given in the first column; detailed results on other coefficients are provided in the Appendix.¹² As can be seen, the monitoring intensity within the firm acts significantly to decrease a worker's wage rate. We also reestimated for those that exert effort and those that do not separately, the coefficient for MONIT for these two subsamples are given in columns 2 and 3, respectively. Accordingly, supervision has a much larger negative impact on the wage rate for those exerting effort, than those that do not, although the latter is not significant¹³. We could think of the regressions in columns 2 and 3 as estimating the gap between the effort supply curves in Figure 1 at two different fixed effort levels a low effort level X_0 and a higher effort level X_1 . At a high level of effort we expect the wage differential between high and low supervision firms to be larger. While this is a valid exercise and supports the predictions of the theoretical model it misses part of the variation in wages. This is because wages depend on effort, which depends on both the level of supervision and the degree of effort intensity in the firm's technology.

Our results of estimating (10) including our effort variable, but using Two Stage Least Squares to take account of the potential endogeneity of this variable using BUSY as

¹² Full results on all other regressions are available from the authors upon request.

¹³ However, it must be noted that the lack of significance could be do to the much smaller sample size.

an instrument, are given in the third column of Table 2.¹⁴ One should note that from the first stage equation it is clear that BUSY acts to increase the level of effort, as would be expected. As can also be seen effort acts to increase earnings as theory would suggest.

Finally, we investigated whether supervision affects the wage rate through effort, as suggested by our theoretical model, by including their interaction term. The inclusion of this interaction term necessitates the use of another instrument due to its endogeneity, and the most natural candidate is the interaction of supervision with our BUSY variable. The first and second stage results for our variables of interest are provided in the last column of Table 2. Accordingly, we still find that EFFORT significantly increases the wage rate. More importantly, however, one can see from the interaction term that this effect decreases with the level of supervision within a firm. It is also notable that the monitoring variable now no longer has a significant impact on wages on its own, only through effort.

Based on the estimated coefficients in column (5) we can perform some simple simulations. If β_m is the estimated coefficient on monitoring, β_{mx} the estimated coefficient on the interaction term and x the level of effort and $(m_1 - m_0)$ a change in the ratio of supervisors, the percentage change in the wage from a one point change in the ratio of supervisors to workers is:

$$\frac{d \ln(w)}{dm} = \frac{\beta_m}{100} + x(m_1 - m_0)\beta_{mx}. \text{ Starting at the mean levels of } x \text{ and } m \text{ and changing } m$$

by one point the results indicate that 1 point increase in the ratio of supervisors to

workers lowers the wage by about 0.9% ($\frac{d \ln(w)}{dm} = \frac{6.14}{100} - 0.74 * (0.01 * 9.5 = -0.009)$).

Given a standard deviation of 12% in the ratio of supervisors to workers we can predict wage differentials of about 11% associated with changes in monitoring across workers.

¹⁴ The need to instrument was confirmed by a simple Hausman test.

Another interpretation for the negative and significant value for β_{mx} is that the returns to effort are negatively associated with monitoring intensity. This is also consistent with the theoretical predictions. When we move onto a higher effort supply curve in Figure 1 (supervision becomes more intensive) we see that the return to effort falls.

Section VI: Conclusion

In this paper we argued that in order to estimate the wage differentials associated with the shirking version of the efficiency wage model it is necessary to control for both effort and supervision, for the interaction between the two, and for the endogeneity of effort. To demonstrate this empirically we use a data set that provides us with reasonable proxies of both effort and supervision, the former of which is notoriously difficult to measure, and a reasonable candidate for instrumenting effort. The empirical results support the predictions of our theoretical model: supervision has a negative and significant impact on wages for high effort workers only. More precisely, when the endogeneity of effort is controlled for, the predicted wage differential is over 10% and returns to effort fall as supervision becomes more intensive.

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Table 1 – Summary Statistics

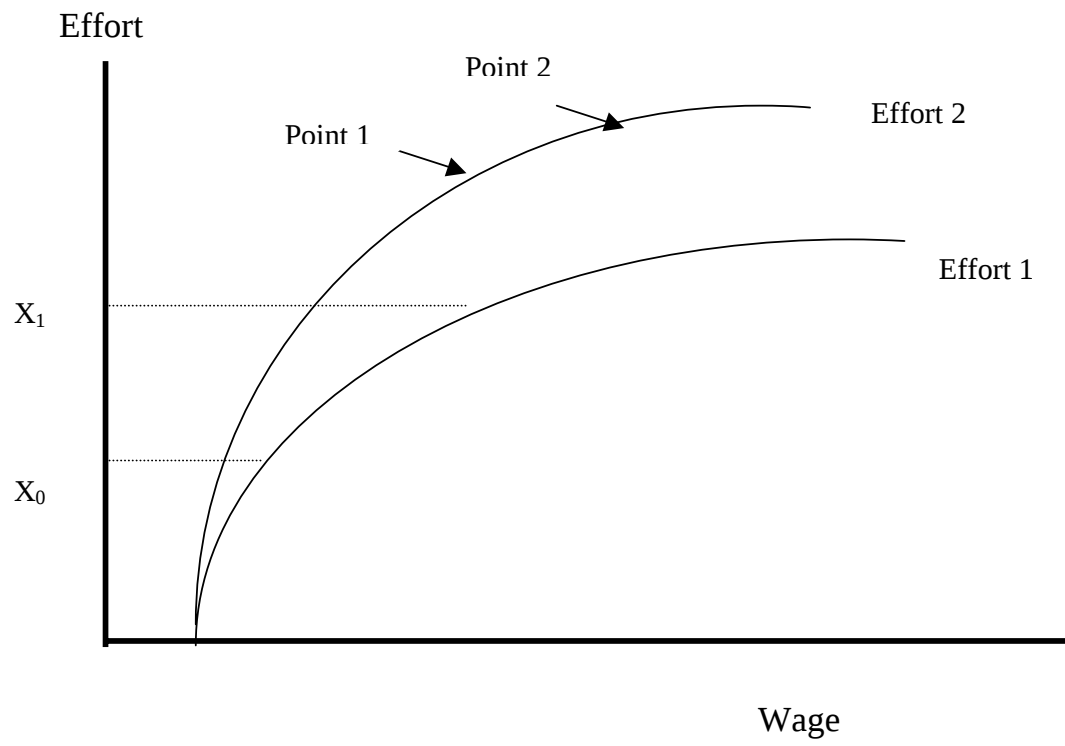
	LOG_WAGE		EFFORT		MONIT	
	<i>Mean</i>	<i>St. Dev.</i>	<i>Mean</i>	<i>St. Dev.</i>	<i>Mean</i>	<i>St. Dev.</i>
Total	1.22	0.86	0.74	0.44	0.17	0.12
EFFORT=1	1.18	0.85	---	---	0.17	0.11
EFFORT=0	1.31	0.87	---	---	0.16	0.12

Table 2 – The Impact of Effort and Monitoring on Earnings

	(1)	(2)	(3)	(4)	(5)
EFFORT	---	---	---	1.4018*	2.51**
				(0.524)	(0.913)
EFFORT*MONIT	---	---	---	---	-9.449*
					(4.389)
MONIT	-0.527**	-0.617**	-0.164	-0.397	6.144
	(0.147)	(0.176)	(0.270)	(0.215)	(3.148)
First Stage					
EFFORT:					
BUSY	---	---	---	0.139**	0.223**
				(0.040)	(0.070)
BUSY*MONIT	---	---	---	---	-0.417
					(0.282)
First Stage					
EFFORT*MONIT:					
BUSY	---	---	---	---	0.060**
					(0.014)
BUSY*MONIT	---	---	---	---	-0.213**
					(0.057)
SAMPLE: EFFORT =	All	1	0	ALL	ALL
N	1464	1061	403	1464	1464
F-Test ($\beta_i=0$)	68.39**	34.63**	16.18**	118.83**	59.97**
R²	0.57	0.59	0.65	0.05	0.08

Notes: (1) Dependent variable is the log hourly wage rate. (2) ** and * are one and five per cent significance levels, respectively. (3) Firm level controls include: employment size, regional location dummies, sector dummies, incidence of state ownership, percentage of union membership, capital intensity, and percentage of foreign ownership of each firm. (4) Worker level controls include level of education, occupation dummies, tenure and its squared value, work experience at the start of the job and its squared value, gender dummy, african dummy, marital status dummy, union membership dummy, and permanent worker status.

Figure 1



Appendix: Detailed Results of Table 1 Column 1

MALE DUMMY	0.208** (0.042)
EDUCATION (YEARS)	0.020** (0.004)
AFRICA DUMMY	-1.237** (0.394)
UNION DUMMY	-0.069 (0.042)
PERMANENT WORKER DUMMY	-0.038 (0.077)
TENURE	0.003 (0.006)
TENURE SQUARED	0.000 (0.000)
MARITAL STATUS DUMMY	0.016 (0.035)
WORK EXPERIENCE AT START OF JOB	0.023** (0.005)
WORK EXPERIENCE AT START OF JOB SQUAR.	-0.000** (0.000)
MONITORING INTENSITY	-0.527** (0.137)
PER CENT FOREIGN OWNERSHIP	0.076 (0.054)
ANY STATE OWNERSHIP DUMMY	-0.268* (0.135)
FIRM SIZE (EMPLOYMENT)	0.001** (0.000)
PER CENT UNIONISED	0.003** (0.001)
Constant	1.620** (0.469)
Observations	1464
F-Test	44.61**
R-squared	0.57

Notes: (1) Dependent variable is the log hourly wage rate. (2) ** and * are one and five per cent significance levels, respectively. (3) Firm level controls also include regional location dummies and sector dummies.