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Centre for Market and Public Organisation
Bristol Institute of Public Affairs
University of Bristol
2 Priory Road
Bristol BS8 1TX

Tel: (0117) 33 10799
Fax: (0117) 33 10705
E-mail: cmpo-office@bristol.ac.uk

Is There a Wage-Supervision Trade-Off? Efficiency Wages Evidence From the 1990 British Workplace Industrial Relations Survey

Andreas P. Georgiadis

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Is there a Wage-Supervision Trade-Off?
Efficiency Wages Evidence From the 1990 British
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Andreas P. Georgiadis*

Centre for International Business and Management (CIBAM), Judge Business School,
University of Cambridge.

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Abstract

Efficiency Wages cannot be ruled out on a priori theoretical grounds and evidence is needed. Direct evidence on the effects of wages on productivity and indirect evidence from the wage structure does not seem persuasive. In this paper we offer an indirect test of the efficiency wage theory, by testing the prediction of the 'shirking' and 'gift-exchange' models of efficiency wages of a wage-supervision trade-off, using data from the 1990 British Workplace Industrial Relations Survey. We highlight the main empirical problems that hinder the estimation of the wage-supervision relationship, and we offer a novel theoretical explanation of the wagesupervision trade-off in terms of union bargaining power. We find evidence that wages and supervision are substitutes in eliciting effort for unskilled manual workers. This evidence supports principal-agent models, many of which do not have the efficiency wage property. Finally, after we test whether wages are set optimally above the market clearing level we fail to find any evidence that can rule out efficiency wages in favour of incentive contracts.

Address for Correspondence
Centre for Market and Public Organisation
Bristol Institute of Public Affairs
University of Bristol
2 Priory Road
Bristol, BS8 1TX
a.georgiadis@jbs.cam.ac.uk
www.bris.ac.uk/Depts/CMPO/

1 Introduction

The main assumption of efficiency wages models and their main deviation from the standard neoclassical or competitive model of the labour market is that wages affect workers productive behaviour.[1] If information about the worker's actions or type is imperfect and the required productive behaviour or quality of workers cannot be enforced or elicited costlessly, then it may be optimal for employers to pay above the worker's outside option[2] or the market clearing wage.[3]

The optimal above-market clearing (efficiency) wage is set so that its marginal benefit[4] is equal to its marginal cost. In general equilibrium, and provided that firms are identical, if firms find optimal to pay an above market clearing wage[5] then this will result in involuntary unemployment, as workers that want to work at a lower than the efficiency wage will not be able to find a job.[6]

Therefore, the efficiency wage theory offers an explanation of involuntary unemployment as it can explain why wages do not fall for the labour market to clear (Akerloff and Yellen 1986, Katz 1986, Weiss 1990). It is also true that efficiency wages theory can explain other labour market phenomena as wage differentials of equally skilled workers (Krueger and Summers 1988, Gibbons and Katz 1992) in the same occupation and dual labour markets (Jones 1985, 1987, Bulow and Summers 1986).

In general the source of the problem is that, according to the efficiency wage theory, wages are used by employers as a personnel policy device to recruit, retain and motivate employees as well as to determine employment (Layard, Nickell and Jackman 1991). Thus,

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[1] In particular higher wages increase workers' effort (Solow 1979, Yellen 1984, Stiglitz 1986) or prevent shirking (Shapiro and Stiglitz 1984), improve the average quality of a firm's applicants pool (Weiss 1980, 1990), decrease quits and turnover (Salop 1979) improve morale and workers association with the firm (Akerloff 1982, 1984), as well as decrease collective disruptive behaviour (union threat) (Dickens 1986).

[2] Alternatively, and in particular under agency problems, employers may use bonding, incentive contracts in which compensation is tied to outcomes (Milgrom and Roberts 1992) or tournaments (Lazear and Rosen 1981) to overcome the problem of asymmetric information. All the above types of labour contracts are more efficient than efficiency wages (Weiss 1990, Milgrom and Roberts 1992), but when they are not feasible, efficiency wages are to be preferred.

[3] It is the wage premium above the market clearing wage and not the wage per se that affects workers' productive behaviour in general equilibrium.

[4] According to the main assumption of efficiency wage models, higher wages generate benefits to firms by increasing profits through higher labour productivity induced through higher effort, and lower turnover, shirking and malfeasance costs.

[5] The market clearing wage is equal to worker's alternative value of time, which is the minimum level of the wage at which employees would be willing to accept the job (the worker's reservation wage). The efficiency wage by construction exceeds the market clearing (reservation) wage by a wage premium that is paid in order to elicit the required behaviour or quality of workers.

[6] gggg

if another mechanism could serve the first role, then firms would pay the lowest possible wage that will satisfy their labour demand and the labour market will clear.[7]

An alternative device to higher wages that serves in motivating and retaining employees is bonding[8]or entry fees which are repaid to workers towards their working lives, where workers are forced to post a bond when join the firm, which they will forfeit when they quit or found shirking (Weiss 1990). Partly for legal reasons or because of capital market imperfections we rarely observe any explicit bonding where workers have to pay a lump sum amount when join the firm (Katz 1986, Rebitzer 1989, Ritter and Taylor 1997) but we do observe entry fees in the form of lower wages for newly hired workers (Lazear 1986, Krueger 1991).

However, lower starting wages and steeper tenure/earnings profiles are subject to moral hazard problems as it is the case that the firm will have an incentive to fire the worker at the timing the entry fee must be refunded (Weiss, 1990). Moreover, bonding cannot be used by firms to tackle any adverse selection problems (Katz 1986, Rebitzer 1989, Weiss 1990, Ritter and Taylor 1997) .

In Dickens, Katz and Lang (1985) it is argued that the payment of efficiency wages cannot be ruled out on a priori theoretical grounds. The main argument against efficiency wages is that, it is not an efficient way to induce motivation or prevent workers malfeasance. The efficient way is bonding,[9] which seems to be limited because of capital market and other constraints, and also because it is observed that employers devote a considerable amount of resources in monitoring (Dickens, Katz and Lang 1985). Given, that bonding is not feasible[10] because of the theoretical considerations above, efficiency wages may be a second best mechanism that elicits productivity and enhances quality of employees.

In sum the relevance of efficiency wages is an empirical not a theoretical question. In particular, whether wages substantially affect aspects of employees' productivity, and whether employers pay efficiency wages as a personnel policy device instead of using alternative mechanisms, are matters that can only be resolved empirically.

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[7]Provided that another mechanism is used to perform the personnel management role of wages, firms would like rationally to set the wage to minus infinity! However, to ensure workers participation firms pay the worker's outside option so that labour supply meets labour demand and the market clears.

[8]This is an efficient mechanism as it does not alter the present discounted value of compensation compared to the full information case (Lazear 1979, 1981, Krueger 1991), but it alters the slope of the tenure/earnings profile.

[9]Efficiency can be also achieved by other forms of incentive contracts that can allocate resources as in the full information case. In the case that private information renders the full information outcome non-feasible, then any incentive efficient contract is to be preferred (Milgrom and Roberts 1992).

[10]See also Weiss 1990, Stiglitz 1987, Ritter and Taylor 1997 for an analytic discussion on the alternatives to efficiency wages and their limitations.

Even though there are numerous empirical studies of efficiency wages, it is generally agreed that there is no convincing evidence of efficiency wages as there are many problems that render the empirical investigation of efficiency wages particularly vexing (Cappelli and Chauvin 1992, Rebitzer 1995). Moreover, different empirical methodologies have been adopted in the empirical analysis of efficiency wages that each has its qualifications and limitations but no methodology seems to address effectively the main empirical problems and provide persuasive evidence that support or dismiss efficiency wage theories (Manning and Thomas 1997, Autor 2003).

In this paper, we provide an empirical test of efficiency wage theory by testing the prediction of the 'shirking' and 'gift-exchange' models of efficiency wages that in equilibrium there is a trade-off between higher wages and supervision using establishment level data from the British Workplace Industrial Relations Survey (WIRS) of 1990.

In the case of unskilled manual employees, we find that the endogeneity bias generated by omission of factors that are correlated with wages and supervision intensity is expected to be positive and thus it may mask any wage-supervision trade-off that may be in operation. This latter finding may provide some support to efficiency wages, as the main omitted factors considered are correlated with wages and supervision only under an efficiency wage rational of wage and supervision determination.

Moreover, we also find evidence of a significant negative relationship between wages and supervision for unskilled manual employees across privately-owned, non-unionised establishments. This finding is not only consistent with efficiency wages, as there are other explanations of the wage-supervision trade-off provided in the literature, one of which is developed in this paper. In particular, our novel theoretical explanation suggests that a negative relationship between wages and supervision may be the result of unobserved differences in union bargaining power across firms when there is firm-union bargaining over effort and unions 'like' wages and 'dislike' supervision.

We further try to sort out alternative theoretical explanations of the wage-supervision trade-off, using the evidence on the sign of the endogeneity bias. Our analysis seems to provide stronger support to the efficiency wage rational of wage/supervision determination-that wages and supervision are substitutes in eliciting higher effort by unskilled manual employees- than alternative theories.

However, as the latter evidence is necessary but not sufficient for the validity of efficiency wages we also test whether employers paid efficiency wages in order to elicit productive behaviour by unskilled manual workers by increasing the wage up to the point where the marginal cost of the wage is exactly offset by a fall in supervision costs. The main conclusion of the test is that we cannot dismiss the

payment of efficiency wages to unskilled manual workers.

For semi-skilled and skilled manual workers, although the pattern of findings is similar to that of unskilled and seems consistent with a positive omitted variable bias, we find no evidence of a significant positive bias in the coefficient of interest and no systematic evidence of a negative relationship between wages and supervision. Finally, in the case of skilled workers we find evidence that provide some support to our prediction that unobserved variation in union bargaining power across establishments may cause a negative bias in the estimated coefficient of supervision intensity included in skilled wage equations.

As the data are not drawn from a particular industry, but for many different sectors throughout the British industry our findings can be generalised and seem to provide some support to the hypothesis that efficiency wages considerations may be valid for relatively less-skilled, low-wage employees which may further imply that the efficiency wage theory could provide particular insight into the workings of low-wage labour markets.

The remainder of the paper is organised as follows: In section 2 we present a review of the empirical studies of the efficiency wage theory and their main qualifications and limitations, whereas in section 3 we present a sketch of our methodology and summarise the main competing theoretical explanations of the wage-supervision trade-off as well as the main empirical problems hindered empirical studies of efficiency wages. In section 4 we present a discussion of the limitations and qualifications of our data and in section 5 we present the estimation results for unskilled, semi-skilled and skilled manual workers. Finally in the last section we offer a summary and the main conclusions of the paper.

2   Review of the Literature

The main empirical question of efficiency wage theory is twofold: Is it true that wages affect workers' productivity? And if it is true then: Do employers consider as optimal to pay above market clearing (efficiency) wages, instead of using alternative devices (for example lower starting wages), to elicit the required productive behaviour or quality of employees? (Cappelli-Chauvin1991, Manning and Thomas 1997).

Testing only a weak form of the above main empirical hypothesis of efficiency wages would be to test whether or not wages affect productivity, which consists a necessary but not sufficient condition[11]

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[11]As discussed above two conditions must be satisfied simultaneously for efficiency wages to hold: a) wages should affect worker's productivity and b) employers should find optimal to set wages above the market clearing level in order to elicit the required action or quality of

for efficiency wages to hold.

There are several studies that test whether or not higher wages contribute to output by estimating production functions with wages included together with other inputs (Wadhwani and Wall 1991, Levine 1992, Konings and Walsh 1994). These kind of studies suffer from the fact that there are unobserved factors that affect productivity and are correlated with wages. In these studies, there is also the econometric problem of identification; Are wages the cause or the result of higher productivity? (Cappelli and Chauvin 1991)

Moreover, as we argued above, this kind of evidence is necessary but not sufficient to make the efficiency wages story valid and that is why it is also important to provide evidence that employers set wages above the market clearing level to induce worker productivity.[12]

The main problem in testing this latter (optimality) condition of efficiency wages is that most of the times the gains of higher productivity or quality of employees induced by higher wages are difficult to measure, as efficiency wages arise in situations where workers' actions and quality are private information (Rebitzer 1995). Moreover, another problem could be that wages are not set unilaterally by employers, as unions and other institutions (minimum wages for example) may intervene in the wage determination process.

The latter point, consists the major criticism of the validity of the findings of one of the most credible attempts to provide evidence on efficiency wages, presented by Cappelli and Chauvin (1991). On the one hand, Cappelli and Chauvin's analysis addresses some of the standard empirical problems discussed above, but on the other hand in their setting, wages are not set unilaterally but are the result of collective bargaining at the company level (Manning and Thomas 1997).[13]

A second type of evidence on efficiency wages is evidence from the wage structure. In particular studies of interindustry wage differentials (Dickens and Katz 1987, Krueger and Summers 1988), provide evidence that unobserved differences in human capital and working conditions cannot explain a major component of the variation in wages, a finding which may suggest that the remaining variation

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employees. The above two conditions are necessary and sufficient for the validity of efficiency wages.

[12]In other words wages are set optimally so that the marginal benefit of the wage is equal to the marginal cost.

[13]Cappelli and Chauvin test empirically the relationship that higher wages are associated with lower level of shirking, that is generated by the Shapiro and Stiglitz (1984) shirking model of efficiency wages. Although, their data allowed them to deal with the identification problem mentioned above and any empirical problems caused by unobserved heterogeneity, their evidence that there is a negative correlation between wages and disciplinary dismissals provides support only to one of the necessary and sufficient conditions of empirical efficiency wages tests, namely that wages affect employees' productive behaviour. However, Autor (2003) explains that this is 'as good as it gets'.

could be attributed to efficiency wages.

However, this evidence does not consist, explicit evidence of efficiency wages as there is a considerable literature on whether these industry effects actually exist (Murphy and Topel 1987, Gibbons and Katz 1992) but even if they do exist, according to Manning and Thomas (1997) their relationship with efficiency wages is tenuous. An explanation of this latter criticism may be that inter-industry wage differentials suggest ex post rents in certain jobs, as suggested by lower turnover and longer tenure in high wage 'premium' jobs (Krueger and Summers 1988), whereas evidence on ex ante rents would potentially be more convincing (Autor 2003).[14]

Additionally, efficiency wages may also offer a potential explanation of why larger firms and firms with higher profits pay higher wages, which consist two well-documented facts in the wage determination literature.[15] However, there is no evidence to support the efficiency wages explanation of the employer size and profit effects on wages (Kruse 1992, Ewing and Payne 1999, Brown -Medoff 1989, Blanchflower et al. 1996).

Given the problems of the above type of empirical studies, alternative ways have been also suggested in order to test the validity of efficiency wages theories. In particular, an indirect way of testing the effect of wages on productivity is to test the relationship between wages and other means of regulating the activities of employees. If high wages elicit productivity or quality enhancing actions from employees then, all else equal, high wages employers should devote fewer resources to monitoring and checking worker activities (Rebitzer 1995).[16]

Particularly, an inverse relationship between wages and supervision intensity is a prediction of both the 'shirking'(Shapiro and Stiglitz 1984) and the 'gift-exchange'(Akerloff 1982) model of efficiency wages, although this occurs via different mechanisms.

In the shirking model[17] an increase in the wage, provided that

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[14]This kind of evidence are provided by Holzer, Katz and Krueger (1991) who find that there exist workers queues in minimum wage jobs which further implies the existence of rents at these jobs. However, once more efficiency wages is one of the potential explanations of the findings of the Holzer et al's study.

[15]For example, as in larger firms it is more difficult to detect shirkers, given everything else equal, wages must rise to prevent shirking (Brown and Medoff 1989, Kruse 1992). Moreover, in the absence of collective bargaining, workers may expect to be paid more if the firm is profitable and to slack off if they are not paid more (rent sharing hypothesis of efficiency wages see Layard et al. 1991)

[16]This holds, given that monitoring increases motivation, as there are theoretical models predicting the opposite (Frey 1992).

[17]Under the shirking framework (Shapiro and Stiglitz 1984) from the worker's decision problem between working and shirking it is derived the so-called 'non-shirking condition' which determines the wage necessary to prevent shirking, as a function of exogenous parameters, including effort. In this version of the shirking model, for simplicity effort is binary (0 if shirk, 1 if work) and monitoring technology is also exogenous. Under a continuous effort version of

everything else is constant, increases the penalty to the shirker when is caught and being dismissed and thus discourages shirking.[18] On the other hand, effort is increasing in monitoring intensity, again ceteris paribus, because this increases the probability of detection of a shirking worker which in turn decreases the expected payoff of shirking and thus induces more motivation. Given that effort is increasing in both the wage and monitoring intensity, we expect that these motivation devices are substitutes in eliciting effort,[19] which implies that, in equilibrium, an increase in the one, for given effort, will result in a decrease in the other.[20]

In other words, in equilibrium, if the wage is increased this will decrease the propensity of a worker to shirk, and for given effort, monitoring intensity must be relaxed and vice versa. Therefore, for given employee's effort there is a trade-off between wages and monitoring intensity.

In the 'gift-exchange' model, supervision is not central to the problem of motivation. Rather firms devote resources to supervision in order to coordinate the activities of the direct producers and ensure product quality ex post (Rebitzer 1995). Under, this model higher pay is considered as a 'gift' that appeals to norms of reciprocity, and thus induces more effort and substitution of self-monitoring for external monitoring. Thus, there are two different

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the shirking model (see chapter 2 and Georgiadis, 2001), the non-shirking condition can be used to express effort as an increasing function of the efficiency wage and monitoring intensity which is usually approximated by the ratio of supervisors to staff.

[18]This can be thought as a substitution effect of an increase in the wage on the worker's effort choice, which means that the shirking model may neglect any income effect of a higher wage on the choice of the effort level by employees. This is because in general the decision of effort supply by employees can be thought as equivalent to the supply of the intensity of work i.e how hard one will work, which can be modelled similarly to labour supply (how much one will work). Thus, an increase in the wage on the one hand increases effort because leisure in terms of shirking becomes more expensive (substitution effect or higher expected cost of shirking) but on the other hand decreases effort, as income increases and given that leisure is a normal good, less effort will be provided (income effect). Since the income effect of a higher wage should be present, strictly speaking the shirking model should implicitly postulate that the income effect is sufficiently small so that effort is increasing in the wage.

[19]The wage premium and monitoring intensity are also substitutes in production. This is because, under a production function with efficient labour inputs (a combination of the number of employees and the intensity they work), an increase in the wage, given everything else constant, increases effort and so output, and thus monitoring intensity must fall for output to remain constant. Therefore, isoquants as well as isoeffort curves slope downwards in the wage-monitoring intensity space. In other words the marginal rate of substitution between wages and monitoring intensity is negative. In general, there are many channels via which wages may affect output and thus wages can be incorporated in the production function directly or indirectly via an effort or quit function for example.

[20]As suggested by Bowles (1995) and Gordon (1990, 1993) inter alia, one should expect that at sufficiently low levels of supervision, wages will have a minor or negligible effect on employees effort, irrespective of how high they are set as the threat of losing the wage premium is not credible. The same holds for supervision intensity at sufficiently low wages. This point doesn't suggest that wages and supervision are complements but instead suggests that isoeffort curves are decreasing and convex in the wage-supervision intensity space.

mechanisms via which the wage-supervision trade-off may result, in efficiency wage theory.[21]

A potential virtue of this testing approach of efficiency wages is that the benefit of the wage can be explicitly measured by gains in terms of supervision costs, which implies that one can test, given an estimate of the wage-supervision trade-off, if the increase in the wage costs is exactly offset by a decrease in supervision costs and thus whether wage increases 'pay for themselves' (Levine 1992). This condition can be quite informative as far as the validity of one of the conditions of efficiency wages discussed above, even under the problems, that arise by unions and other institutional interventions in the wage determination.[22]

Empirical tests of efficiency wages that are based on the investigation of the relationship between wages and supervision have been mainly hindered by the problem of endogeneity bias in the estimates of interest. The first two sources of endogeneity bias are omitted variables and simultaneity, as the supervisor to staff ratio which is the most usual proxy for the intensity of monitoring, is endogeneously and simultaneously determined with wages (Groshen and Krueger 1990, Krueger 1991, Rebitzer 1995). The third source of endogeneity is due to measurement error, again resulting because of the use of the ratio of supervisors to staff as a proxy for monitoring, as it may be the case that supervisors spend only a fraction of their time monitoring production employees (Rebitzer 1995, Brunello 1995).

Another important criticism, that is often been neglected in the literature, is that testing the wage-supervision trade-off is not equivalent as testing efficiency wages, firstly because there are also other explanations of the trade-off than efficiency wages (Kruse 1992) and second because any evidence of a wage-supervision trade-off is viewed as indirect evidence of effects of wages on workers productive behaviour, which is a necessary but not a sufficient condition for the validity of efficiency wages (see following sections).

Some of the empirical studies of the relationship between wages and monitoring or supervision include Fitzroy and Kraft (1986),

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[21]There is a subtle difference between the two models. In the gift-exchange model, employers set wages directly and via wages supervision intensity is also determined. Thus, under this model wage changes have an effect on supervision because wages appeal to norms of reciprocity and not the other way around. In the contrary in the shirking model a change in the wage have an effect on the level of supervision and vice versa.

[22]In the presense of collective bargaining and given that there are valid efficiency wages considerations, under certain conditions, we would expect that the minimum level that the wage can be set is the efficiency wage. Therefore, if the comparison of marginal benefit and marginal cost of the wage suggests that wages are set below the efficiency wage level, and provided that union bargaining over wages imposes another binding constraint on wage determination, then this can be clearly interpeted as evidence that dismiss the validity of efficiency wages, even under union intervention.

Leonard (1987), Neal (1993), Brunello(1995). Fitzroy and Kraft (1986), investigate the effects of profit-sharing on factors' productivity using a sample of workers from 65 West German firms from the metalworking industry, and find an insignificant effect of the ratio of skilled to unskilled workers on profit sharing income of employees. Moreover, Leonard (1987) estimated wage equations including as a proxy for monitoring the supervisor to staff ratio for six occupations in a sample of US high-technology firms but finds a positive and insignificant relationship between pay and supervision in all occupations.

Similarly, Neal (1993) uses supervision data from the 1977 wave of the Panel Survey of Income Dynamics, in order to investigate whether interindustry wage differentials can be explained by differences in supervision by particularly looking whether workers in high wage industries enjoy more autonomy on the job which is an implication of dual labour markets arising from differences in monitoring problems (Bulow and Summers 1986). Neal finds that workers in high-wage industries are at least as intensively supervised as low-wage, secondary sector workers, and that no evidence can be provided that inter-industry differences in monitoring contribute to inter-industry wage differentials.

Brunello (1995) explores the relationship between pay and both the quantity and quality of supervision using data from the New Earnings Survey over the period between 1975-1982. The main finding arising from Brunello's analysis is that the wage-supervision trade-off turns insignificant once the quality of supervision is included in the wage equation which further suggests that errors in the measurement of supervision affect the outcome of the empirical investigation of the wage-supervision trade-off.

Finally Goldin (1986) suggests that sex segregation across jobs within manufacturing and the standardisation and division of tasks in female dominated occupations that made monitoring easier may explain the finding that there is sex-discrimination over pay in manufacturing.

Two other studies that find evidence that supports the wage supervision trade-off are presented by Kruse (1992) and Ewing and Payne (1999). Kruse estimates wage equations using data from the 1980 Survey of Jobs Characteristics, and he finds evidence that supports a negative relationship between wage and supervision. In particular, Kruse (1992) finds that daily supervised workers receive 1.2 per cent lower pay than their weekly supervised colleagues, ceteris paribus.

Similarly, Ewing and Payne (1999) using a sample of workers from the National Longitudinal Survey of Youth, find a negative relationship between their measure of supervision and reported wages. The common criticism of all the above studies is that they suffer from

the endogeneity problem discussed above.[23]

Very few studies have managed to tackle the endogeneity problem successfully by exploiting policy or other interventions, which cause exogenous and independent variation in the intensity of supervision. In fact we know three such studies;

One of these studies is presented by Groshen and Krueger (1990), who exploit the fact that the number of supervisors to staff in the U.S hospital industry is often regulated by state and local (city) authorities and that is why the mandated supervisor-to-staff ratio varies by occupation and city. Thus, differences in the regulated supervisor-to-staff ratio, across standard metropolitan statistical areas in BLS data cause exogenous variation in the supervisor/supervisee ratio. Groshen and Krueger find evidence in favour of a trade-off between wages and supervision only for the nursing occupation.

The second study is presented by Krueger (1991), who exploits the institutional arrangements of the franchise system in the fast food industry, which are the reason for inferior monitoring in company owned relative to franchisee-owned outlets. Krueger, finds that compensation is not only higher in company compared to franchisee-owned outlets, but it is also increasing faster with tenure in company-owned outlets.

Finally, Rebitzer (1995) exploits the fact that in petrochemical industry there are contract employees who are working in the plant, and their recruitment, payment and other employment practices are determined by the contractor employer who sets an agreement with the host employer. However, because of the high risk on the job in petrochemical plants, the host employer must also monitor contract employees, for safety reasons. Thus, host supervision is uncorrelated with the wage and other employment practices. Again Rebitzer finds evidence in favour of the trade-off between wages and supervision.

A limitation of the above three studies is related to their main virtue, as they are focusing on specific industries, where specific conditions allow investigators to address the endogeneity problem and thus their results cannot be generalised. Finally, another major problem that is shared between all studies of the wage-supervision trade-off (irrespective if they address the endogeneity problem or not) is that they fail to sort out alternative explanations of the

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[23]Brunello (1995) and Brown and Sessions (2002) use instruments for supervision intensity but the validity of their instruments is based on strong assumptions. Furthermore, there are studies which suggest that the endogeneity bias is expected to be positive and thus to mask any wage-supervision trade-off in operation, a claim that may explain why some of the studies discussed in this section rendered inconclusive. The positive sign of the endogeneity bias is often used as an argument to support the validity of the findings of studies that found a negative wage-supervision relationship and that do not effectively address the endogeneity problem (Kruse 1992, Ewing and Payne 1999, Brown and Sessions 2002).

wage-supervision trade-off[24] but even if this is the case, another problem is that any evidence of a wage-supervision trade-off arising from agency problems cannot be considered as evidence in support of efficiency wages (see following sections).

3 Endogeneity and the Wage-Supervision Relationship

As discussed in the previous section the main problem of empirical studies that try to identify if there is a wage-supervision intensity trade-off by standard estimation of wage equations with a measure of supervision being one of the explanatory variables, is the endogeneity of the supervision variable. One of the most effective ways to tackle the endogeneity problem is to exploit policy or other interventions that generate exogenous and independent variation in supervision intensity, as the studies discussed in the previous section that find valid instruments for the endogenous supervision variable (Wooldridge 2001, Cameron and Trivedi 2005). However, exploiting appropriate policy or other interventions and thus finding valid instruments is not an easy task and that is why, as suggested in the previous section there exist very few studies that manage to do so (Groshen and Krueger 1990, Krueger 1991, Rebitzer 1995).

Alternatively, when instrumental variables estimation is not possible, one may be able to reduce the endogeneity bias in the estimates of the wage-supervision relationship by using regression to control for confounding factors that are the likely source of endogeneity. Then it may be possible that one can use the observed sign of the estimate of the wage-supervision relationship produced by the regressions and any evidence on the direction of the omitted variable bias to infer the sign of the true relationship between wages and supervision.[25]

Standard econometric theory (Greene 2000) suggests that in the face of endogeneity, the direction of the OLS bias in the estimated coefficient of interest depends on the relationship between the main unobserved influences with the dependent and the endogenous variable respectively. In particular in the wage-supervision estimation,

[24]For example in Krueger (1991) an alternative interpetation of the finding of a wage-supervision trade-off except of that of more acute agency problems in company-owned restaurants is provided by 'expense preference' where managers in company owned fast food restaurants make their lives easier by paying higher wages at the expense of the company. This has the same empirical implications as efficiency wages except that it is not efficient (Autor 2003).

[25]For example if the regressions produce evidence of a wage-supervision trade-off, and there is also evidence that controlling for potential omitted factors leads to a more negative estimated coefficient of the effect of supervision intensity on wages, and thus the omitted variable bias is positive, then one can be quite confident that the sign of the true relationship between wages and supervision is negative, and thus there exists a wage-supervision trade-off.

the direction of the endogeneity bias depends on the correlation of the main omitted variables with wages and supervision. However, one can argue that the nature of the main omitted factors and their relationship with wages and supervision depend on the rationale underlying the wage and supervision determination mechanism.

Thus, theory can be informative about the main unobserved factors that may cause a bias in the estimate of the wage-supervision relationship. This is why in the next sections we present the main theories of wage-supervision determination in the literature, as this is essential in our attempt to determine the main omitted factors and thus to predict the direction of the endogeneity bias.

In general, different theoretical models of wage/supervision determination point towards different omitted factors. Thus, including controls for the omitted factors suggested by a theoretical model of wage/supervision determination may be indicative of whether the model is relevant, as evidence that the inclusion of these controls in the regressions leads to a reduction in the bias of the coefficient of interest may provide support to the theoretical model. Similarly if the inclusion of the controls suggested by a theoretical model does not lead to any change in the coefficient of interest, then this may be viewed as evidence that the data does not provide support to this model. Therefore, the latter approach may be a potential way for the econometrician to sort out alternative theoretical explanations of a negative or positive wage/supervision relationship.

Although the above method may provide a valid attempt to reduce the endogeneity bias of the coefficient of interest, to infer the sign of the true wage/supervision relationship and to sort out alternative theoretical explanations, it may not achieve identification of the true magnitude of the wage-supervision relationship. As discussed above for identification one needs exogenous and independent variation in the causing variable of interest (here supervision intensity), whereas our analysis exploits a different source of variation.

In particular, we exploit variation in supervision intensity generated by regional and industry variation in the skilled/unskilled wage differential which in turns produces variation in the cost of supervision across establishments. Other sources of variation we are exploiting may be regional differences in the unemployment rate, which according to the shirking model affect the probability of finding a job and thus affect the expected penalty of shirking and monitoring intensity.

Having said all the above, and provided that we also face the same problems hindering the estimation of the relationship between wages and supervision as previous studies in the field (Leonard 1987, Neal 1993, Brunello 1995, Ewing and Payne 1999), our main contribution is to investigate the relationship between wages and supervision using establishment level data from the UK, and thus provide some

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fresh evidence in the existing literature.

3.1 Efficiency Wages

Under a continuous effort version of the shirking model (Albrecht and Vroman 1998), employee's optimally chosen effort is a function of the wage and supervision intensity set by the employer, as well as other factors:

$$e = e(w, N/L, R), e_i > 0, e_{ii} < 0, i = w, N/L, R \ (1)$$

,where w is the wage, N/L is the ratio of supervisors to workers and R are all other factors that affect the intensity of effort chosen by employees.[26] By fixing effort to a certain level, the wage can be expressed as an implicit function of monitoring intensity as well as all other factors that affect effort. This wage function is given by:

$$w = f(N/L, e^*, R) \ (2)$$

, where e^* can be thought as the level of required effort by the firm. Equation (2) is the equation of the contour of the effort function that defines the set of firm's isoeffort curves. It can be easily shown that isoeffort curves slope downwards in $(w, N/L)$ space, as the derivative of the wage with respect to monitoring intensity is given by:

$$\frac{dw}{d(N/L)} = -\frac{e_{N/L}}{e_w} < 0 \ (3)$$

Provided the shape of the isoeffort curves and the fact that the representative firm will choose wages, supervision as well as other human resource practices to minimize the costs of a unit of labour that provides the target effort e^*, the optimal wage-supervision determination is illustrated in figure 1. The wage-supervision relationship illustrated in figure 1 is determined for given all other factors that affect the intensity of effort R (other personnel policy practices that affect effort such as screening and motivation mechanisms) in the firm, which further suggests that inability to observe and control for these factors will generate an upward bias in the relationship of interest (see also Rebitzer 1995).

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[26]Note that these factors can be endogenous to the firm as for example other human resource practices (recruitment and motivation practices, etc.) or exogenous, as the discount rate, the worker's outside option, etc. as the shirking framework postulates.
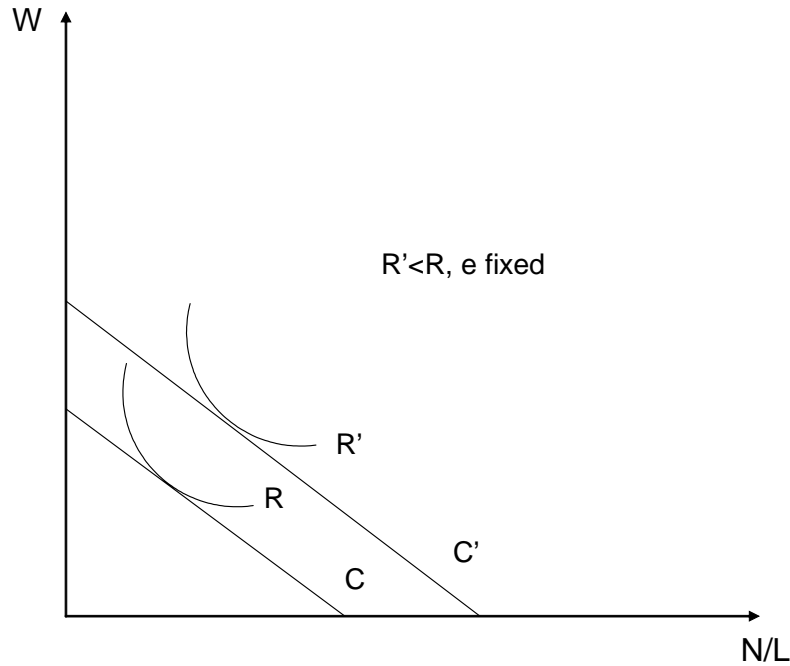
Figure 1: The effect of a change in effort determinants R in the optimal level
of wages and supervision.

Note that according to the latter argument endogeneity may result because of unobserved factors that affect the choice of wage and supervision by firms with the same effort requirements. Moreover, firms may differ in terms of the effort target they set for many reasons[27] and therefore may require that their employees work harder and thus choose higher wages and supervision intensity.

Thus, the above example illustrates that under the efficiency wages shirking rationale, the main omitted variables are required effort at the firm level or/and effort influencing variables, as for example other personnel and human resource practices and the en-

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[27]For example firms that consider product quality as a competitive advantage they will require employees to work harder and thus set higher wages and supervision (Kruse 1992). Similarly, businesses for which there is higher hazard on the job will require more caution and diligence by their employees which can be interpreted as higher effort which again can be achieved by more tight supervision and higher wages. Finally, in establishments where shirking costs are higher than elsewhere and if shirking is viewed as withheld and thus lower effort, it is optimal that managers use more stringent supervision and pay higher wages so that to ensure that effort is sufficiently high.

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dogeneity bias is expected to be positive and thus will mask any underlying wage-supervision trade-off that may be in operation.

This is not surprising as according to the shirking model the predicted negative relationship between wages and supervision is generated for everything else constant and in particular for given effort. Therefore, if the shirking model is true, controlling for effort differences as well as factors that may influence effort intensity across firms is important as it enables one to trace-out the wage-supervision trade-off along an isoeffort curve and if this is not done the result will be an upward bias in the relationship of interest.[28]

Another equivalent theoretical approach to the estimation of the wage-monitoring intensity relationship has been to start with a production function in efficient labour units, define the equation of the isoquants in $(w, N/L)$ space and use that to express the wage as an implicit function of monitoring intensity and other factors that affect output.

The production function is given by:

$$Q = Q[e(w, N/L) * L], Q_i > 0, Q_{ii} < 0, i = e * L, \ (4)$$

If we hold output constant and provided that the functional form of the effort function allows to explicitly solve for wages, then the wage can be expressed by the following equation:

$$w = g(N/L, Q^*, L), \ (5)$$

, where Q^* is the fixed level of output. It is easy to infer that the slope of the isoquants in $(w, N/L)$ space is negative.[29] Nevertheless, as in the case discussed above, and given that the true technological relationship has as postulated in equation (4), inability to control for output as well as employment[30] will shift the relationship between wages and supervision intensity resulting in upward biased estimates of the wage-supervision relationship.

This latter approach is used by Leonard (1987) who also suggests that there will be an upward bias in the estimate of interest in the case one does not control for output or other unobserved factors affecting output. Leonard uses employment to control for output and he implicitly suggests that the fact that he estimates wage equations

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[28] This argument is also demonstrated by the theoretical developed model in chapter 2, where after an exogenous increase in the wage because of the imposition of a binding minimum wage, and given that effort is continuous and is not held constant, employers increase monitoring intensity. In other words, employers who want to increase the effort level they will use higher wages and more intensive supervision.

[29] In particular it is exactly the same as the slope of the isoeffort curves, derived in the previous section.

[30] Even if one controls for output, differences in employment across firms will also generate differences in the effort required to produce a given output which again leads to an upward bias in the wage-supervision relationship.

for narrowly defined occupations may limit any unobserved heterogeneity across firms that may cause an upward bias. However, first of all employment may not be a good proxy for output (Groshen and Krueger 1990) and second there may still exist some unobserved heterogeneity in narrowly defined occupations across firms (for example different effort requirements for firm-specific reasons) that may explain why Leonard finds positive but insignificant effects of supervision on wages as a positive endogeneity bias may mask the wage-supervision trade-off. An alternative way to deal with the output bias when one follows this latter approach, could be to control for both effort and employment in order to identify any trade-off between wages and supervision along an isoquant.[31]

Even in the case that one controls for both output and employment, the trade-off between wages and supervision intensity may not be traced out along an isoquant, as different firms may have different effort and/or production technologies.[32] Given, that the latter argument is true this would mean that firms with more responsive effort, provided everything else is the same, will use both higher wages and more supervision, fact which generates an additional positive bias in the estimate of interest. Therefore, one needs not only to control for the level of effort but also for differences in the effort function across firms. The question of interest thus becomes also how one could determine potential ways to control for effort technology differences across firms.

Gordon (1994) conducted a cross-country analysis on variation of supervision intensity and suggested that wages and supervision are more effective in inducing motivation and effort in some countries, because of cross-national differences on the systems that gov-

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[31]Controling for both effort and employment, given that the production function is as postulated by equation (4), is equivalent to controling for output, provided also that the effort and production technology is the same across firms. The usefulness of this approach is that it can be used to trace out the trade-off along an isoquant, without being necessary to explicitly control for output in the abscence of data on output and when data on effort and employment are available.

[32]Suppose that firms do not differ in the production technology but differ in the effort technology only, i.e. the effort function is differerent across firms or alternatively the responsiveness of effort in the wage and supervision is different for different firms. In this case if we keep output and employment fixed, given the same production technology in all firms we also control for effort level, because if all firms have the same output target and use the same amount of labour then they should also use the same level of effort to achieve the output target, given production technology is the same across firms. However, if firms differ in the effort technology, they will use a different mix of the wage and supervision intensity to achieve the same effort level, and it is quite intuitive why the more effort productive firms will use less of both wage and supervision to achieve the given effort level. This is an intuitive explanation of why we expect that differences in effort technology can be another source of a positive bias in the relationship between wages and supervision. We discuss a way to control for differences in effort technology in this section. Similarly, differences in production technology (assume effort technology the same across firms for simplicity), across firms can cause shifts and thus a positive bias in the relationship between wages and supervision.

ern labour relations. Particularly, Gordon (1994) points out that differences in labour management institutions and work norms may generate differences in the effectiveness of carrots and sticks as incentive devices.

The relevant literature, is using either continuous or categorical differences across economies in order to distinguish between 'corporatist' and 'competitive' systems or 'cooperative' and 'conflictual' regimes of labour relations respectively (Gordon 1990). One should expect heavy reliance of conflictual regimes on wages and supervision and lower reliance on these devices in cooperative regimes (Gordon 1994).

Gordon's factor analysis results suggested that out of many structural characteristics of labour relations systems two factors were those with the highest explanatory power. The first factor was labelled as an index of "income and job security", since high scores on this factor indicate low inter-industry wage dispersion, high government commitment to health services, an active government labour market policy, relatively high union-density, and reasonable protection against layoffs (including prenotification, maximum weeks of unemployment benefits, and mandatory severance benefits). The second factor was labeled as a measure of "worker bargaining power" since it loads most highly on the degree of coordination of union bargaining, mandatory prenotification and union density. Based on the literature, we would expect economic systems with higher indices of "income and job security" and "worker bargaining power" to feature relatively more "cooperative" where we should expect lower responsiveness of effort on the carrot (the wage) and the stick (supervision intensity). Thus, the idea is to try to control for firms' features or characteristics that may indicate whether labour relations is of a "conflictual" or of a "cooperative" type (see the data section).

As in the case of Leonard (1987) the above discussion regarding the direction of the endogeneity bias casts doubt on the findings of some of the most cited attempts to estimate the relationship between wages and supervision and may also explain why these studies rendered inconclusive (Fitzroy and Kraft, 1986, Neal 1993, Brunello 1995).

One of the main objectives of the above analysis is to emphasise that the 'shirking' and 'gift-exchange' models are predicting a wage-supervision trade-off, ceteris paribus. Therefore, one cannot dismiss efficiency wages in favour of alternative theories[33] if he/she cannot

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[33]Theories that are consistent with a positive relationship between wages and supervision are: a) equalizing differences models (Rosen 1986), where supervision is considered by employees as a 'bad' working condition and thus, ceteris paribus, employees should be paid a compensating wage-differential, when they are supervised more stringently. b) Effort discipline (Bowles 1985, Bowles and Boyer 1988) models, where the wage and supervision are viewed as complements in inducing effort, as an increase in the wage cannot induce effort,

find a negative relationship between wages and supervision, unless firstly he/she explicitly controls for all required factors.[34]

This is something that seems not to be explicitly suggested in many studies in the field. An exception is the fast-food industry study presented by Krueger (1991), who argues that fast food jobs are highly homogeneous in skills and performance requirements and thus there is limited scope for unobserved heterogeneity across fast food outlets that could bias the estimate of interest.

Additionally, Groshen and Krueger (1990), implicitly assume that given that they examine the wage-supervision relationship for narrowly defined occupations, effort requirements or other related unobserved factors should not vary much for the same occupation across hospitals. However, they do find a significant hospital specific effect on wages, which could be explained also by differences in effort requirements across hospitals. If differences in effort requirements is a valid explanation for the hospital specific effect on wages, and if there are valid efficiency wages considerations, then we should expect that there would be also a positive hospital specific effect on supervision. In fact this effect is not documented by Groshen and Krueger but this is not because differences in the intensity of effort is not a potential explanation, but because of minimum supervision intensity requirements which are imposed by state and federal government across areas, and constrain optimal adjustments of supervision intensity.

3.2 Employees Quality Sorting

Another theoretical explanation of a negative relationship between wages and supervision is provided by the so-called "sorting by ability" model which is based on the assumption that more able employees that are paid higher wages could be left more autonomy on the job as they need less guidance and coordination. Therefore, un-

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if it is not accompanied by supervision increases, because dismissal threats are not credible unless there is sufficient monitoring. c) Product differentiation theories as firms that are more concerned about the quality of their product will pay higher wages and supervise employees more stringently (Kruse 1992), d) Finally, occupational differences may also explain a positive relationship between wages and supervision, because in some occupations employees are paid higher wages and are supervised more tightly (this happens usually when there is high-risk in terms of safety, as for example in the Petrochemical industry (Rebitzer 1995)).

[34]In general, the efficiency wage effect can work through inreased motivation but also through improved quality of the workforce. Therefore, for the econometrician to be able to trace-out the trade-off between wages and supervision, he/she must control for both employees performance and quality differences. This argument is also demonstrated in Georgiadis (2001), where a positive relationship between wages and supervision is the case, in a shirking model with heterogeneous workers and/or continuous effort, as an increase in the wage enables the firm to improve the quality of the workforce and/or increase effort on the job. Therefore it is also important to control also for employees heterogeneity, when estimating the wage-supervision relationship.

der this theory, profit maximizing employers will increase the wage up to the point where the improvement in employees' quality will be such that the increase in wage costs is exactly offset by a fall in supervision costs (Groshen and Krueger 1990). Thus, this model is not only consistent with a wage-supervision trade-off but also predicts that in equilibrium wage costs should be offset by supervision costs which is exactly what is predicted by the shirking model of efficiency wages.

Therefore, under this theoretical framework, unobserved differences in employees' quality across firms or establishments will lead to a negative bias in the wage-supervision relationship. Therefore, unless one finds a valid instrument or effectively controls for employees' ability it is hard to conclude that any evidence on a wage-supervision trade-off provides evidence in support of efficiency wages. However, note that if the true relationship between wages and supervision is as the "sorting by ability" model postulates, then if one controls for employees' quality then the wage supervision relationship is expected to be positive.[35]

The close observational equivalence between the "sorting by ability" and efficiency wages theories with respect to the wage-supervision trade-off not only causes problems in sorting out the two models in the light of evidence supporting a trade-off but has a result the problem to persist even if one shows that wage increases pay for themselves by lower supervision costs, which is an extra condition used to test whether employers pay efficiency wages (Levine 1992, Rebitzer 1995). The only difference between the two models seems to be the fact that for efficiency wages, wages and supervision are effort/productivity eliciting devices and the trade-off is predicted ceteris paribus, whereas in the "sorting by ability" model, wages and supervision interact through any quality adjustments in the workforce, and the trade-off is the case for varying employees' ability across firms.[36]

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[35]In the 'sorting by ability' model 'isoability' curves slope upwards in the wage-monitoring intensity space because an increase in the wage must be followed by an increase in supervision intensity in order for ability to be constant. This is because on the one hand an increase in the wage increases average ability of the workforce because enables employers to employ more able workers, but on the other hand an increase in supervision intensity will enable the employer to substitute less able for more able employees, to keep average employees' quality constant, as less able workers need to be supervised more stringently. If one does not control for differences in employees quality/ability across establishments and provided that the sorting by ability model is true, this will generate shifts in the isoability curves across establishments which will have as a result a negative relationship between wages and supervision to be traced out.

[36]The theoretical model of chapter 2 assumes heterogeneous employees in terms of their innate inclination to shirk and predicts that an increase in the wage will have as an effect that the marginal worker will have higher disutility of effort compared to the situation before the wage increase. Moreover, the wage increase will affect the distribution of characteristic between workers and shirkers and increase the average inclination to shirk of workers compared to that of shirkers. Therefore the wage-supervision trade-off is predicted under this

3.3 Unions

In this subsection we offer another but novel explanation of the wage-supervision trade-off, based on the premise that wages and supervision are the result of firm-union collective bargaining arrangements.

In particular, the analysis is based on the theoretical framework presented in Georgiadis (2001) with a suitable extension to include union-firm bargaining over effort. In Georgiadis (2001), the firm's objective is to maximise profits subject to the non-shirking condition which expresses average effort (the non-shirking condition can also express the proportion of non-shirkers, under this framework) as a function of the wage and supervision intensity as well as other factors.

In the absence of unions, the firm's problem is:

$$\max_{w,N,L} \Pi = f(\theta * L) - wL - cN \quad (6)$$
$$s.t \ \theta = \theta(w, N/L, R) \quad (7)$$

, where θ is the average effort which depends on the wage w, monitoring intensity as captured by the supervisor to staff ratio N/L and other exogenous parameters that affect workers inclination to shirk R (worker's outside option, discount rate, quit rate etc.). For expositional purposes and for simplicity we will assume that the firm's objective is to maximise profits per employee. Under the simplified assumption of constant returns to scale in efficient labour units and after substituting (7) to (6) the firm's problem becomes:

$$\max_{w,N/L} \pi = f[\theta(w, N/L)] - w - c\frac{N}{L} \quad (8)$$

, which implies that firm's problem can be reduced in choosing the wage and monitoring intensity and in this way average effort to maximise profits per worker π.

On the other hand, we will assume that union's objective is to maximise the average utility of unionised workers that are employed by the firm. Therefore, union's utility or objective function can be expressed by the following equation:

$$V = w - \theta(w, N/L) \quad (9)$$

, where w is the wage of the average employee in the firm, which is equal to the wage set by the firm, as in the model developed in Georgiadis (2001) all workers are paid the same wage and θ is the average effort in the firm. Therefore, given the objective functions

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framework for given average effort in the firm (or proportion of non-shirkers) and average "quality"/characteristic of workers.

of both parties and provided also that both parties have a zero fallback, the solution of the bargaining game[37] will be the solution of the following maximisation problem:

$$\max_{w, N/L} \Omega = V^{\alpha} * \pi^{\beta} \ (10)$$

, where Ω is known as the Nash maximand (Nash 1950, 1953) and α, β are parameters that capture union's and firm's bargaining power respectively (usually dependent on the two parties discount rates and outside options).

As it may be the case that some times unions bargain over manning ratios, for example the level at which machines or offices are manned or sometimes in trains or ships the crew size, or in general how hard workers have to work, it is reasonable to assume that the union and the firm bargain over effort,[38] which is an approach often adopted also by others (Layard Nickell and Jackman 1991).

For our purpose, which is to predict any effects that may arise from bargaining between unions and employers, under efficiency wages considerations, on the wage-supervision intensity relationship, it is sufficient to provide a diagrammatic illustration of the bargaining solution (see figure 2). Therefore, given that the union and the firm bargain over average effort which in turn is determined by the level of the wage and monitoring intensity, the bargaining solution can be illustrated in the $(w, N/L)$ space. It is easy to show that the contours of the firm's objective function are elliptic, as the indifference curves are arising from satiated preferences. Moreover, as we explained previously, because of the wage-supervision intensity trade-off, for given effort, we expect that the average isoeffort curves slope downwards in $(w, N/L)$ space.

Finally, it can be shown that union's indifference curves slope upwards in $(w, N/L)$ space,[39] which is derived from union's objective function, that postulates that unions "like" wages and "dislike" supervision.

As, it is shown in figure 2,[40] if there is an increase in the union's bargaining power, we expect that the outcome of the bargaining process will involve higher wage and lower supervision intensity and probably lower average effort, as the equilibrium shifts in a

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[37]This is the standard alternating offer bargaining game over the division of a pie between two parties, under full information on both sides about the payoffs to the other side.

[38]The fact that unions bargain over wages and supervision intensity which determine the level of effort also imply that unions implicitly bargain over the determinaton of effort.

[39]The slope of union's indifference curves in $(w, N/L)$ space is : $\frac{dw}{dN/L} = -\frac{V_{N/L}}{V_w} = -\frac{\theta_{N/L}}{1-\theta_w}$, which is positive as $\theta_{N/L}$ is positive as effort is increasing in supervision intensity, and it can be also shown that $\theta_w < 1$, by chapter 2.

[40]We use P to denote the firm's eliptic isoprofit curves, u for unions indifferences curves and e for isoeffort curves in the (W,N/L) space.

higher union indifference curve. This result implies that differences in union's bargaining power across unionised firms may cause a negative bias in the wage-supervision intensity, which may be another explanation of a negative relationship between wages and supervision.[41]
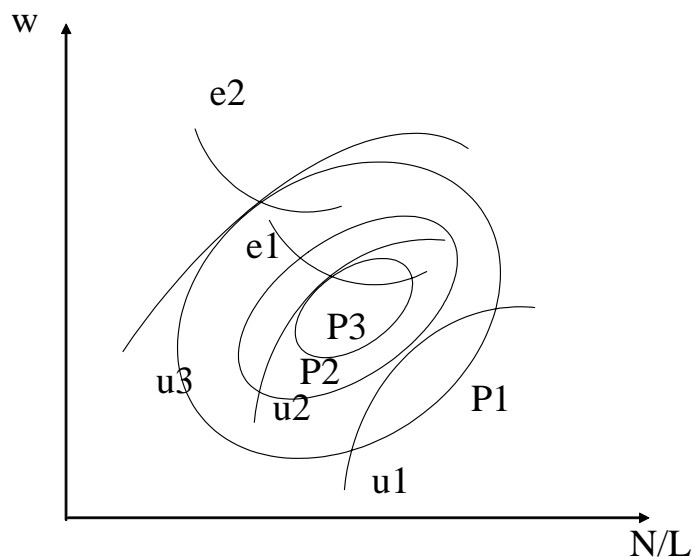
Figure 2: The determination of the wage and supervision by union-firm bargaining and the 'union-power' bias.

Thus, under this theoretical framework the main variable is the union's bargaining power which if omitted from the wage specification the result will be a downward bias in the wage-supervision relationship. This result may cast doubt on the findings of empirical studies that suggested that their evidence of a wage-supervision trade-off are made more compelling by the fact that any omitted variable bias is expected to be positive (Leonard 1987, Ewing and Payne 1999).

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[41]This prediction holds, under the assumption that union's objective function is such that unions "like" wages and "dislike" supervision.

In conclusion, we show that under reasonable assumptions, union-firm bargaining may offer another explanation, of the wage-supervision trade-off, which is something that should be also taken seriously in mind and hasn't been addressed by any previous study in the topic.

3.4 Equalizing Differences and Workers Preferences over Supervision

In the previous section we show how union's preferences over wages and supervision may explain the wage-supervision trade-off when unions bargain over wages and/or working conditions (supervision and effort intensity).

The theory of equalizing differences explains observed wage-dispersion across firms and establishments by postulating that workers must receive a wage-differential in order to be compensated for differential working conditions across firms. In our case this simply implies that if supervision intensity is viewed by workers as an important feature of working conditions in the establishment, then workers' preferences over supervision intensity will determine the level and differences in compensation across establishments.

If for example workers "dislike" supervision because they "dislike" effort and because in the presence of supervision they have to supply more effort than in the absence of supervision (Groshen and Krueger 1990) then employees working in firms with higher supervision should receive higher wages, ceteris paribus. According to Groshen and Krueger (1990) another reason why employees 'dislike' monitoring is because they may consider it as a disagreeable intrusion in their privacy and independence. Therefore, if supervision is viewed by employees simply as a bad working condition and not as a motivation device, then a positive relationship between wages and supervision is the case.

On the other hand if workers "like" supervision because for example tight supervision enables them to achieve job goals (Groshen and Krueger 1990) then a negative wage differential must be paid to employees in establishments where supervision is more intensive. Therefore another explanation of the wage-supervision trade-off can be provided by equalizing differences theory, under the assumption that supervision is a 'good' working condition.

The above discussion is based on homogeneous employees' preferences over supervision. Under the case where employees' have heterogeneous preferences over supervision intensity then the sign of the wage differential paid by employers depends on the preferences of the marginal worker (Groshen and Krueger 1990).[42] All in all, the

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[42]If one assumes that all employees either 'like' or 'dislike' supervision but the extent they

main point of this section is that another interpretation of the wage-supervision trade-off may be provided by equalizing differences theory under unobserved employees preferences, when employees 'like' supervision.

3.5 Principal-Agent Theories

The fact that there exist many different theoretical explanations[43] of the wage-supervision trade-off suggests that even if one provides consistent evidence that support the wage-supervision trade-off doesn't necessarily mean that this evidence provide also support to efficiency wages. However, even in the case where all alternative to efficiency wages explanations of the wage-supervision trade-off are ruled out, the findings should be still interpreted with caution. Provided that all alternative explanations have been dismissed the most plausible interpretation of a negative wage-supervision relationship should be as supporting one of the tenets of efficiency wages that wages and supervision are substitutes in inducing employee effort and motivation.

Even in this case, this finding is not sufficient to provide support to efficiency wages as the trade-off between wages and supervision arising from agency problems is also predicted by agency theories many of which do not share the efficiency wages property.[44]

Therefore testing if there is a wage-supervision trade-off and showing that the trade-off arises because of agency problems is equivalent as testing a necessary but not sufficient condition for efficiency wages as this provides only indirect evidence of effects of wages on employees' productivity. The latter is a fundamental assumption of efficiency wages but another fundamental feature or implication of efficiency wages is that employers find it optimal to set the wage unilaterally above the market clearing wage in order to maximize profits.

Therefore, in order to test for efficiency wages one needs to show firstly that a wage-supervision trade-off exists and then that the

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do that varies across employees, then the sign of the wage differential depends on the nature of preferences of employees over supervision, whereas the magnitude of any wage differential depends on the extent the marginal worker 'likes'or 'dislikes' supervision.

[43] Another explanation of the wage-supervision trade-off may be provided by unobserved occupational differences across firms, that lead to lower wages and higher supervision (Goldin 1986, Kruse 1992). By unobserved occupational differences we mean any occupational differences that are not due to differences in effort requirements or/and employees' quality across establishments, which are expected to be picked up by any employees' quality and effort controls.

[44] Efficiency wages should be seen as a special case of principal-agent theories of motivation, where there is a lower bound in the compensation the agent can receive under any state. In other words the distinguishing feature of efficiency wages is that wages are set above the market clearing wage.

trade-off is consistent with a principal-agent wage and not any alternative rationale. The latter test will reveal whether wages affect workers' productive behaviour, which if holds then one needs also to test whether wages are set optimally to elicit the required productive behaviour by employees by testing whether the costs from wage increases are offset by a fall in supervision costs.

4 Other Considerations

4.1 Substitution of Supervisors for Workers

Furthermore, on the endogeneity problem related to the supervisor-staff ratio, Groshen and Krueger (1990), using a standard minimisation argument and a standard Cobb-Douglas production function depending on supervisory and labour inputs, they show that an increase in the wage will increase the supervisor/supervisee ratio, in any case where the production technology allows for a non-zero marginal rate of substitution between supervision and employment, because of substitution of supervisors for workers,[45] leading to a positive bias in the estimate of the relationship between wage and supervision. It is very intuitive why this is the case under Groshen and Krueger's chosen setting as the wage is exogenous and does not affect productivity, and that is why an increase in the wage renders labour input relatively more cheap than the supervisory input leading to substitution of supervisors for workers.

Nevertheless, if we instead assume that the underlying technology is as postulated in (4), where output depends on efficient labour units, and if we assume that the wage is given because for example of a binding minimum wage in the labour market, the same minimisation argument can be used to show that, it may be also the case, that an exogenous increase in the wage, may also decrease the supervisor to staff ratio, depending on the responsiveness of the marginal product of labour relative to the marginal product of supervision w.r.t the wage).[46]

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[45] This argument is based on the fact that the production function is of the standard neoclassical type, with supervision and labour the only direct and non-inferior inputs to production, and with given input prices to the firm. Under this framework, an exogenous increase in the wage tilts the isocost so that the tangency with the isoquant of the target output is at a point at which more supervisory input is used relative to labour input.

[46] In Georgiadis (2001) the effect of the wage on the marginal product of both labour and supervision is ambiguous, but it can be shown that they are moving always in the same direction. In the case that both marginal products increase, it is shown that the changes are such that the supervisor/supervisee relative use in production must be increased. In the case, where both marginal products are decreasing then the change in the supervisor-to staff ratio depends on the relative responsiveness of the marginal product of labour and supervision w.r.t the wage. However, it is shown that other restrictions is the reason why the ratio of supervisor to staff increases even under this latter case.

If we assume that the production technology is given by equation (4), then cost minimisation implies that

$$\frac{MPL}{MPN} = \frac{w}{c}, \ (11)$$

,where MPL and MPN are the marginal product of employment and supervision and w and c are the price of labour and supervision respectively, which we assume that they are given. Under this case, both the MPL and MPN are dependent on the wage. Suppose now that the wage is given by a minimum wage (see Georgiadis, 2001).[47] An increase in the wage, has an ambiguous effect on the supervisor/supervisee ratio, as the change depends on the relative responsiveness of MPL and MPN to the wage increase.

The main aim of this section is to show that the prediction of Groshen and Krueger (1990) hinges heavily on the particular theoretical setting they use at which the wage is exogenous, whereas under efficiency wages as well in empirical studies of the wage-supervision trade-off the wage is treated as endogenous.

Moreover, we show that, under efficiency wages and in the special case the wage is increased exogenously the effect on the supervisor/supervisee is ambiguous. Finally, it is important also to point out that under the efficiency wage framework, even if the production function allows for substitution of supervisors for workers an increase in the wage will result in a fall in the ratio of supervisors to workers, if effort is held constant. This argument suggests that, given that the production function is as postulated by (4), controlling for effort will prevent any substitution effect to mask an underlying wage-supervision trade-off.

4.2   Measurement Error

Other problems associated with the trade-off are measurement error problems related to the use of supervisor to staff ratio. In particular, Rebitzer (1995) argues that supervisors do not have a solely monitoring responsibility on the job and there are supervisory workers that do not have any monitoring role at all and thus the supervising to supervised employees ratio overstates the intensity of monitoring.

Actually, we believe that this is mainly a problem of definition and even if monitoring is not the only task of supervisory employees who may contribute explicitly to production, it remains their main task and thus the supervisor to staff ratio is expected to be highly

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[47]Otherwise this argument cannot be applied as the wage is endogenous in efficiency wages models.

correlated with the extend of monitoring (Odiorne 1963, Gordon 1990 and 1994).[48]

Finally, Brunello (1995) considered quantity of supervision, represented by the supervisor to staff ratio, as only one dimension of monitoring, and suggested that quality of supervision should be also taken into account. After finding that the inclusion of quality in wage equations abates the wage-supervision trade-off concludes that measurement error in the main variables should stressed out as another major problem that hinders the identification of the relationship of interest. However, in the case that one finds a negative estimate of the wage-supervision relationship, and provided that measurement error attenuates the estimate of interest, the trade-off becomes more compelling (see estimation section).

5   The Data

The data set we used is drawn from the British Workplace Industrial Relations Survey (WIRS) of 1990. This establishment-level survey provides information on a sample of more than two thousands establishments, with 25 or more employees, from almost all sectors of the UK economy. Except of the fact the data are not drawn from a specific sector and thus any results can be generalised, another strength of the WIRS data is that it includes information on supervision, wages and other determinants of wages that are important for our analysis.

In particular, the workforce is decomposed into manual and non-manual employees, where the manual workers category is further decomposed by skill (unskilled, semi-skilled and skilled) and the non-manual is decomposed by occupation (managers, technicians, supervisors/foremen etc.). In the subcategory of supervisors/foremen are included all supervisors/foremen of manual workers and administrative/clerical workers with supervisory responsibilities. This category excludes all non-manual workers with other responsibilities and some supervisory responsibilities as well, fact which suggests that includes all non-manual workers with primary and main duties the supervision of manual/clerical workforce. Therefore, the monitoring intensity proxy we construct is the ratio of supervisors/ foremen to the total number of manual and clerical workers.[49]

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[48]Gordon (1990) defines supervisory inputs as those wage-and-salary employees of a firm with considerable if not primary responsibility for monitoring the labor effort of those below them in the firm's hierarchy, especially including the labour effort of production workers.

[49]We believe that the WIRS definition of the supervisor /foremen category limits concerns for the standard measurement error problem, where the supervisor to staff ratio is expected to overestimate the extent of monitoring, as foremen of manual workers and clerical workers with supervisory responsibilities have as a main task the monitoring and inspection of manual and clerical employees. Thus, given the WIRS 1990 definitions, the supervisors to staff ratio

The focus of attention in this paper will be on the determination of wages of the three different skill categories of manual workers. Note that even though WIRS is a survey of 2061 establishments, wages are reported for the majority gender in each skill group only in establishments where there are more than five employees in skill group.[50]

Another important strength of WIRS for the purpose of our analysis is that it offers information on potential controls for workers' effort. Particularly in the management questionnaire includes information on the ratio of all other costs share to labour costs share in total costs which is often considered as a good proxy of the intensity at which employees may work with capital equipment or machines (Layard, Jackman and Nickell 1991) and therefore a good proxy for the extent of shirking costs as smaller relative labour share is likely to be associated with higher shirking costs,[51] because this may imply that workers may work with more expensive equipment than establishments with larger relative labour share (Katz 1986).

On the other hand another proxy for effort seems to be provided by answers to questions on the intensity of work in the establishment surveyed, relative to other establishments in the same industry.

The WIRS 90 includes detailed information on unions and collective bargaining arrangements as well as other features of labour and industrial relations, which are essential in order to control for 'effort technology' and for differences in union bargaining power across establishments. In order to measure differences in industrial relations regimes that determine the responsiveness of employees effort in the wage and supervision and thus some features of effort technology across establishments we use information of provision of extra employees' benefits as sick pay over and above statutory requirements, free or subsidized food or meals, occupational pension and a standard working week of less than 36 hours. Additionally, we use also the proportion of employees dismissed for reasons other than redundancy and the proportion of employees received disciplinary sanctions. We expect that these variables will pick up some of the degree of conflict or cooperation that characterises labour-management relations in the establishment and thus any differences in the responsiveness of effort in motivation devices, as the wage and supervision.

Moreover, union power bias considerations, as suggested by the

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in our case may not systematically overestimate monitoring intensity in the establishment.

[50]Considering also missing observations because of non-response even in establishments with more than five employees in skill group or because of responses of "don't know" or "non applicability" of the particular question in some establishments, the remaining observations on unskilled, semi-skilled and skilled median wages are 1232, 990 and 1105 respectively.

[51]Unobserved differences in shirking costs are expected to be the source of a positive bias in the estimate of the elasticity of the wage with respect to supervision (Leonard 1987, Neal 1993).

theoretical analysis in one of the previous sections may be particularly valid in this case because a significant proportion of establishments in WIRS 90 are unionised but also because in an important fraction of unionised establishments, unions negotiate not only over pay and physical working conditions but also over manning and staffing levels, recruitment, level of redundancy payments and other issues.[52] In order to control for differences in union bargaining power across establishments we use a dummy for whether or not a recognised union negotiates also over staffing and manning levels and other issues for manual workers but also a dummy for the existence of a closed shop.

The justification of the choice of the closed shop dummy as a good measure of differences in bargaining power is that union bargaining strength comes in large part from the strike threat. A union with a closed shop arrangement at a particular establishment will be in a stronger position to call a strike than one without. A union's bargaining strength is reduced when there is a non-union pool of suitably qualified labour that an employer can hire from to cut costs. The likelihood of this is reduced and thus the bargaining strength of the union increased, where there is a closed shop (Stewart 1987, Stewart 1990, Machin, Stewart and Van Reenen 1993).

Our previous analysis also suggested that if the prediction of the shirking model that wages and supervision are substitutes in motivating employees then a positive bias is predicted to occur in the estimate of the relationship of interest because of omission of effort intensity controls, as well as other human resource practices that affect effort and thus the choice of wages and supervision by personnel managers. The information included in WIRS allows us also to construct controls for other motivation devices that may be used in establishments and thus to verify the direction of the bias (if any) generated by omitting these controls. In particular, WIRS 90 includes detailed information on merit pay across skill groups and whether appraisal of employees is used for promotions or pay rises.

In our analysis that follows we also try to provide an alternative test of the wage-supervision trade-off based on the conjecture that if there exist a wage-supervision trade-off in operation, then it is likely to be more pronounced for firms in the private sector and non-unionised firms, as these firms are expected to be in a better position to take advantage of the trade-off because of cost minimizing behaviour and greater flexibility in adjusting pay and staff levels compared to unionised or/and public sector firms. This is the reason why we also restrict estimation in this particular subsample of firms, where the trade-off is expected to be more pronounced.

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[52]Strikingly in 1047 out of 1236 unionised establishments there exist a recognised union that negotiates not only over pay but also on staffing and manning levels and other issues as suggested above.

The focus on the sample of non-unionised and privately owned establishments becomes even more appealing if one also considers that the essence of efficiency wages is the unilateral (no other forces, as unions are expected to affect wage-determination) and optimal (profit maximising and cost minimising behaviour is more likely to be the case in the private sector) setting of wages above the market-clearing wage from employers.

An offsetting weakness of the WIRS 1990 is the lack of detailed information on employees quality and characteristics, as well as detailed occupation information. However, we believe that the fact that in our study we address the problem separately for the wages of unskilled, semi-skilled and skilled manual workers should significantly reduce heterogeneity in worker quality or any unobserved variation due to occupational differences. Finally, the use of other controls that may capture the average human capital and technology in the establishment also abates this problem.

6 Estimation

6.1 Unskilled

Tables 1 to 3 summarise the main estimation results of semi-log wage equations for unskilled manual workers (see tables section at the end). Estimated specifications are of the form of equation (2), which is the equation of the isoeffort curve produced by the production function.

The dependent variable is the natural logarithm of the median weekly wage of the majority gender in the unskilled manual group[53] and the main explanatory variables, except the supervisors to staff ratio, are some of the establishment characteristics (size, industry affiliation, union recognition, ownership, etc.) that according to the literature (Groshen 1991, Stewart 1987, 1990) are the main determinants of inter-establishments wage differentials.

In table 1 we present estimation results for the full sample of establishments in WIRS 1990. Results from the first estimated specification suggest a positive but insignificant relationship between wages and the supervisor to staff ratio, and a positive wage-differential for unskilled manual workers in establishments that have more employees (not reported in table 1),[54] but also a positive wage differential for employees in establishments that are in manufactur-

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[53]The wage data are grouped into intervals and that is why wage equations are estimated by maximum likelihood which, under broad conditions, produces consistent, asymptotically normal and asymptotically efficient estimates of the parameters of interest (Stewart 1983).

[54]The establishment size dummies are positive, monotonically increasing and jointly significant but individually insignificant.

ing and in trading (private) sector as well as in establishments where there is a recognised union.[55]

Specification (2) includes also controls for the decomposition of unskilled manual workforce in terms of gender and the decomposition of total manual workforce in terms of part-time status. Estimates indicate that unskilled manual workers are paid on average lower wages in establishments with higher proportion of female employees in the unskilled manual group, but the same is not the case for establishments with higher proportion of part time manual workers.[56]

In general controls for workforce characteristics may pick up differences in observed average quality of unskilled manual employees across establishments, and thus may provide an indication of any unobserved employees' quality/ability bias, provided that observed workers' quality characteristics are correlated with unobserved. Under the latter assumption, the inclusion of employees' quality controls suggests that any unobserved ability or 'employee quality' bias seems to be quite sizeable in magnitude, although the wage data are from a relatively homogeneous group of workers across establishments. Moreover, the change in the estimate of interest generated by the inclusion of manual workforce' characteristics suggests that any unobserved employees' quality bias is positive, in contrast to the 'sorting by ability' model that predicts a negative unobserved ability bias in the estimated coefficient of monitoring intensity.[57]

Specification (3) includes dummies for the ratio of all other costs share to labour costs share in total costs which are expected to pick up differences in effort intensity or shirking costs across establishments, as discussed in the previous section. The inclusion of the effort intensity (or shirking costs) proxies in specification (3) results in a downward change in the estimated coefficient of the supervisor to staff ratio and seems to support our prediction that unobserved differences in the intensity of effort across establishments cause an upward bias in the estimate of the wage-supervision relationship that masks any wage-supervision trade-off. Moreover, the same doesn't

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[55]Note that coefficients in models with grouped dependent variable are interpreted in the standard OLS fashion (Stewart 1983).

[56]The estimated coefficient of the proportion of part-time employees in the manual employees group is in the fringe of statistical significance.

[57]Stewart (1983) showed that maximum likelihood estimators (MLEs) of the parameters of a linear model, with a normal homoscedastic error, where the dependent variable is grouped, are equivalent to OLS estimators of the parameters of the model produced by the regression of the conditional mean of the dependent variable on the exogenous variables, where conditioning is not only on exogenous variables but also on the interval in which the true value of the dependent variable is included. The conditional mean is calculated based on an initial random guess of values of estimated parameters and an iterated procedure is used up to convergence in order to determine the optimal estimated parameters. Therefore, because of the OLS equivalence of the MLE for the interval regression model, the standard OLS omitted variable bias formula can be used in order to predict the direction of any omitted variable bias.

seem to be the case when dummies for the intensity of work in the establishment, as reported by manual workers representative in the workplace, are also included in the estimated specification (see specification (4) in table 1).[58]

Similarly, we find that the inclusion of controls for differences in 'effort technology' and of controls for the use of other personnel policies that aim to motivate employees does not cause a significant change in the coefficient of interest, as implied by estimation results for specification (5) and (6) of table 1.[59]

Therefore, as the pattern of change in the coefficient of supervisor to staff ratio doesn't seem to indicate any sign of support of a wage-supervision trade-off in the case of the full–sample of establishments (except of some evidence in favour of an upward effort intensity bias), as suggested by our analysis in the previous sections, we next turn to present estimation results from private (trading) sector establishments.

The focus to the private sector is justified by the discussion in the previous section which suggests that if the wage-supervision trade-off is a result of cost-minimising behaviour of firms, as implied by the shirking but also by the 'sorting by ability' model, then a wage-supervision trade-off is expected to be more pronounced in private sector establishments which are more likely to exhibit a cost-minimising behaviour compared to establishments in the public sector.

Estimation results for the trading sector are presented in table 2. In this case the pattern of change in the coefficient of interest across different specifications which gradually include controls for workforce characteristics, effort intensity, effort technology as well as controls for practices that aim in motivating manual employees seems consistent with a wage-supervision trade-off, although the wage-supervision relationship changes from positive and insignificant to negative and insignificant.

In particular, we fail to find any evidence of a negative bias due to unobserved workers' quality as it would be the case if the 'sorting by ability' model would be true, because again the inclusion of controls

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[58] A Hausman specification test is used throughout in order to test whether the change in the coefficient of interest generated by the inclusion of extra and relevant to the theory controls is significant. In other words, the Hausman test is used to check whether unobserved variation of factors that according to the 'shirking' model are expected to be correlated with wages and supervision, may cause a bias in the estimated coefficient of supervision intensity. Results of the Hausman test suggest that although the inclusion of relative costs ratio dummies generate a significant downward change in the coefficient of monitoring intensity, the same is not the case with subjective work intensity dummies.

[59] Note also, that although the findings indicate an increase in the coefficient of monitoring intensity, when we control for union bargaining power, a Hausman test suggests that the there is no significant and systematic negative 'union' bias, as predicted by the theoretical model presented in one of the previous sections.

for manual workforce characteristics causes a significant decrease in the magnitude of the coefficient of interest.

Moreover, controlling for effort intensity turns the coefficient of supervision intensity from positive to negative but the coefficient remains insignificant. This finding is consistent with one of the points of the analysis of the previous sections, that if wages and supervision intensity are substitutes in eliciting effort from employees, then differences in the intensity of work across establishments is expected to generate an upward bias which may mask a negative relationship between wages and supervision.

Additionally, the inclusion of 'effort technology' and 'other motivation devices' controls seems to provide further support to the hypothesis that if wages and supervision are effort extracting devices, then a positive endogeneity bias will be the result of unobserved variation in factors that are correlated with the intensity and the responsiveness of employees' effort.

Effort technology controls include a dummy for employees' benefits in the establishment as sick pay, free or subsidized meals and an occupational pension over the standard employee pension, as well as the proportion of employees dismissed or sanctioned over the last year for disciplinary reasons. These variables are expected to pick up how 'conflictual' or 'cooperative' are labour relations regimes across establishments, which in turn according to Gordon (1990, 1994) may indicate how responsive is employees' effort in motivation devices as supervision and wages.

The wage-supervision trade-off increases in magnitude when 'effort technology' controls are included, as indicated in specification (5) but the trade-off is statistically insignificant. This finding may support our prediction that if wages and supervision are effort regulating devices, then excluding factors that determine the nature of labour relations across establishments and thus the responsiveness of employees' effort to personnel motivation practices, will cause an upward bias in the coefficient of supervision, as we would expect that in establishments with more 'conflictual' labour relations effort will be more responsive in both wages and supervision and thus these establishments will tend to pay higher wages and supervise their employees more stringently.

As suggested in the analysis of the previous sections, the endogeneity bias of the wage-supervision relationship is expected to be positive if wages and supervision are determined according to the efficiency wage rationale to elicit productive behaviour by employees, because in establishments that managers implement human resource practices that affect employees' productivity (which are unobserved by the econometrician), wages and supervision are expected to be lower compared to other establishments.

Estimates of the relationship of interest from specification (6)

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that includes controls for whether there is merit pay for unskilled manual workers and for whether appraisal systems are used for pay rise and promotion for all employees in the establishment seem to provide further support to the latter prediction.

In general, the results of estimation of wage equations from the sample of establishments in the trading sector seem to indicate that a wage-supervision trade-off may be masked by upward omitted variable bias.[60]

As the latter pattern is stronger in the private sector sample than the full sample of establishments, we next look at estimation results in the particular subsample of private and non-unionised establishments. The subsample of privately owned and non-unionized establishments seems to be more interesting for the test of the wage-supervision trade-off mainly because of three reasons.

The first reason is because private and non-unionised establishments are expected to have higher ability and incentive to take advantage of the wage-supervision trade-off, as unionised establishments, may be limited in their ability to adjust wages and staffing levels and government-owned establishments may not have the same cost-minimisation incentives as privately owned establishments (Groshen and Krueger 1990).

Moreover the fact that the essence of efficiency wages is the unilateral and optimal setting of wages above the market clearing level by employers in order to overcome asymmetric information problems, renders the private and non-unionised sector the ideal one to test the validity of efficiency wages. Finally, the last reason for the selection of the private and non-unionised sector is that there are no considerations of a negative 'union power' bias in this sector private and non-unionised sample of establishments, and thus one of the explanations of the wage-supervision trade-off is dismissed.[61]

Thus, based on the later rationale, if the wage-supervision trade-off holds and since it is expected to be more pronounced for private and non-unionised establishments, it will be easier for one to trace out the trade-off in this sector, after also trying to reduce any con-

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[60] A Hausman test rejects the null that the coefficient of supervisors to staff in specification (2) is equal to the same coefficient in specification (6), which further suggests that there is a significant positive bias resulting by the exclusion of effort related controls, as effort intensity and technology, and motivation practices. Furthermore, although we find that when a dummy for a closed shop and a dummy for whether union negotiates over staffing and working conditions dummies as well as pay are included in the estimated specification, the coefficient of the supervisor to staff ratio increases, a Hasman test suggests that the change is not significant.

[61] The evidence produced by the full and trading sector samples does not support the prediction that a significant bias due to unobserved differences in union power across establishments is the case. Neverthless, the pattern of change in the coefficient of interest among specifications with and without union power controls seems to be consistent with our theoretical prediction of a negative union power bias that is based on the premise that unions negotiate over effort and that they 'like' wages and 'dislike' supervision.

cerns of an upward bias in the coefficient of interest by controlling for the relevant factors.

The latter conjecture seems to be supported by the results presented in table 3, as the estimate of the relationship between wages and supervision becomes from positive and insignificant, negative and significant, after controlling for all effort related factors discussed above. A Hausman specification test supports the hypothesis that a significant positive bias is the case once the effort related controls are excluded from the estimated specification. Moreover, effort related controls as controls for effort intensity, for effort technology, and other motivation devices are jointly but also individually significant. Finally, once more we fail to find any evidence that supports a negative unobserved ability bias, provided that workforce characteristics controls are correlated with unobserved workforce quality. In particular, we find that in private and non-unionised establishments that employ an extra supervisor per manual (and clerical) employee wages are 0.06% lower.

In general, we find evidence that seems to support an efficiency wage rationale of the wage and supervision determination and which further suggests that the endogeneity bias in the estimated relationship between wages and supervision is expected to be positive and thus it may mask the wage-supervision trade-off. Moreover, after we restrict our analysis to the private and non-unionised establishments, where we expect that any wage supervision trade-off will be more pronounced, we manage to trace-out a negative relationship between wages and supervision.

The discussion presented in the previous sections indicates that there are more than one theoretical explanations of the wage-supervision trade-off. In particular, sorting out alternative theoretical explanations is another major problem that hinders many empirical studies in the field and a problem that is difficult to solve, as suggested by Groshen and Krueger (1990) and Kruse (1992).

A negative relationship between wages and supervision can be explained by: a) efficiency wages (the 'shirking' and the 'gift-exchange' versions of efficiency wage theory), b) the 'sorting by ability' model (or unobserved employees' quality, c) the theory of 'equalising differences', where supervision is viewed by employees as a 'good' working condition, d) (unobserved) occupational differences, e) and as we show in one of the previous sectors by differences in union bargaining power, when wages and supervision are determined by collective bargaining, and unions 'like' wages and 'dislike' supervision.

The 'sorting' by ability model is generally considered as the most difficult to be distinguished by efficiency wages because as also suggested by Groshen and Krueger (1990), this model is not only consistent with a wage-supervision trade-off but also with the prediction that in equilibrium, an increase in wage costs will be exactly offset

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by a fall in supervision costs.[62]

Although we estimate wage equations across establishments for a homogeneous in skills group of workers, there may still be unobserved ability differences that may be correlated with supervision intensity. This is the reason why we expect that the inclusion of controls for workforce characteristics such as the proportion of female employees in the unskilled manual group and the proportion of part-time employees in all manual employees may also pick up some of the differences in employees' quality.[63]

However, the evidence in this section suggests that, provided that observed quality characteristics are correlated with unobserved, any unobserved employee quality bias doesn't seem to have the sign predicted by the 'sorting by ability' model. Moreover, we also find that the wage-supervision trade-off is generated after controlling for omitted factors (effort intensity, effort technology, etc.) that are relevant for the wage-supervision determination, based on an efficiency wage shirking rationale. This latter finding seems to provide support to the 'shirking' rather than the unobserved ability explanations of the wage-supervision trade-off.

Finally, in the 'sorting by ability' model, the wage and supervision are used as devices to determine the quality of the workforce and effort is exogenous in this model. Thus, one should expect that if the 'sorting by ability' model is true, a wage-supervision trade-off should have been the case irrespective of the inclusion of effort related controls in the estimated specifications, which is not the case here.[64]

Hence, if the sorting by ability model was actually the case we wouldn't expect that any wage-supervision trade-off would be traced out after we have controlled for effort related factors, as the latter is the exact prediction of the 'shirking' model and a relationship that arises from the non-shirking condition or the equation of isoeffort curves. Therefore, the latter discussion suggests that the 'sorting' by ability model does not seem to reconcile with the evidence of the trade-off from this section.

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[62] In the shirking model an increase in the wage will cause an increase in wage costs but because higher wages increase effort, wage costs will be exactly offset by a fall in supervision costs. In the 'sorting by ability' model an increase in the wage will enable firms to hire better quality employees who need less supervision and thus the higher wage costs will be offset by a fall in supervision costs.

[63] Industry dummies may also pick up some of employee quality differences.

[64] In one of the previous sections we suggested that based on the 'sorting by ability' model isoability curves slope upwards in the wage-supervision intensity space and thus unobserved differences in ability/quality of employees across establishments will generate shifts in the isoability curves across establishments which will lead to a negative relationship between wages and supervision to be traced-out. As shifts in the isoability curves are independent of any changes in effort we would expect that, if the sorting by ability model is true, the wage-supervision trade-off would have been the case, irrespective of the inclusion of effort controls, which is not true here.

Additionally, the same arguments could be used in order to dismiss the claim that the wage-supervision trade-off is attributed to unobserved occupational differences,[65] as if occupational differences can explain the trade-off (Kruse 1992) then we should expect that controls for effort intensity, technology and other personnel motivation processes would be irrelevant, and thus the trade-off would be traced out, with or without those controls which is not the case here.

In the case that effort related controls are relevant because they are correlated with unobserved occupational differences then as the evidence suggests occupational differences will be consistent with a positive and not a negative relationship between wages and supervision. Finally, we could argue that occupational differences in general may be also due to differences in the 'effort' (in terms of intensity, diligence, etc.) and the 'quality' requirements by employees, in which case the effort and employees quality controls are expected to pick up some of the effect of occupational factors.[66] Thus, to the extent that observed occupational factors are correlated with unobserved, we could claim that occupational differences do not seem as a very appealing explanation of the wage-supervision trade-off, in this case.

Furthermore, equalising differences could explain the negative relationship between wages and supervision, if employees' 'like' supervision and thus they are willing to accept lower wages in the case they are supervised more stringently. However, in this case the evidence imply a positive association of wages and supervision that operates via effort intensity and effort technology as well as through the relationship of wages and supervision intensity with other human resources motivation practices. Therefore, the evidence seems not to support a systematic negative association of wages and supervision because of employees preferences over supervision, as we find that the direction of the bias suggests that in establishments with higher supervision intensity (because of higher effort intensity requirements or more responsive effort or because of the limited use of other motivating practices) wages are also higher.[67] Equalising differences may be consistent with the finding of the positive effort bias in the estimate of the wage-supervision relationship, because

[65] Unobserved occupational differences may arise in our case as we don't have any detailed information on occupational characteristics.

[66] Another reason for occupational differences is job hazard which we should expect that will cause a positive bias in the wage-supervision relationship, as when employees should be more cautious because of high probability of job accident, they should be paid a higher wage and be monitored more stringently. Other controls in our specifications as the dummy for establishment in manufacturing or services may also pick up any occupational differences.

[67] Alternatively, the evidence of the upward effort bias may be also consistent with the fact that wages and supervision are both negatively associated with effort and motivation, but even in this case a positive association between wages and supervision holds.

higher supervision intensity has as a result higher effort and higher wages provided that employees dislike putting effort on the job. The latter argument suggests that the findings may provide more support to an equalising differences explanation of a positive rather than a negative wage-supervision relationship.

Therefore, as the wage-supervision trade-off is estimated for a sample of non-unionised private-owned establishments, the 'union-power' explanation of a negative relationship between wages and supervision does not apply in this case, and thus based on the above discussion, the evidence seem to be mostly consistent with the tenet of efficiency wages, that wages and supervision are substitutes effort regulating inputs.[68]

Moreover, as discussed above this can be interpreted as indirect evidence that wages affect employees productive behaviour, which as suggested in the previous sections is a necessary but not sufficient condition for the validity of efficiency wages. In other words the evidence seem to support one of the main assumptions of efficiency wages that wages affect employees productivity, but this doesn't necessarily imply that employers choose to pay higher wages in order to elicit productivity, as there are other alternatives in motivating employees except of efficiency wages.[69]

As suggested in one of the previous sections, this evidence is better to be interpreted as providing support to principal-agent models, many of which do not have the efficiency wage property. Thus, another condition that needs to be satisfied in order that the efficiency wages story is valid in the case of unskilled manual workers, is that employers set wages optimally so that wage costs are offset by a fall in supervision costs.

We would expect that the above test can be based on the wage-supervision trade-off estimate from the sample of private owned, non-unionised establishments as in these establishments wages are more likely to be determined unilaterally by employers. The estimate of wage costs produced by a 1% increase in the wage of unskilled manual employees is £1.25 per employee as the average wage of unskilled manual employees is £125.72.[70] Based on sample estimates a 1% increase in the wage is expected on average to cause

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[68] Even if the above arguments are not considered as sufficient to rule out all alternative theoretical explanations of the wage-supervision trade-off in favour of efficiency wages, they do support the hypothesis that there are valid efficiency wage effects on wage-determination.

[69] In theory the standard alternatives to efficiency wages are incentive contracts as for example piece-rate contracts, bonding or steeper tenure-earnings profiles, and tournaments. Moreover, profit or ownership sharing may be another alternative.

[70] As the wage observations are grouped, the average wage of unskilled manual workers is estimated by an interval regression of unskilled wages on a constant. The estimate of the constant is the estimate of the conditional expectation of the latent unobserved unskilled manual wage variable, where conditioning is on the interval that includes the true value of the dependent variable.

a fall in supervision costs per employee equal to £38.12. Therefore our calculations suggest that the wage is set so that the marginal benefit of the higher wage exceeds the marginal cost, which further suggests that wages for unskilled manual workers have been set at a lower level than the efficiency wage, as at the efficiency wage level a marginal increase in the wage and thus in wage costs is equal to the fall in supervision costs that is generated by the wage increase.[71]

However, this latter finding cannot be used to dismiss the hypothesis that employers may pay efficiency wages, as our estimate of the trade-off may be moderated by the endogeneity bias and measurement error,[72] and thus in the presence of these problems the wage-supervision trade-off is made even more compelling.[73] Therefore, all in all the evidence in this section seem to support the main tenet of efficiency wages that wages affect employees productive behaviour and cannot dismiss efficiency wages in favour of other alternative motivation schemes.[74]

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[71]This condition tests whether wages are set optimally at the efficiency wage level and not whether wages are above market clearing. However, provided that the outside option of unskilled manual employees is the average wage they can get in the non-unionised and public sector (which is the lowest wage an unskilled manual worker can get is he/she leaves his/her job) then one could argue that wages in the trading, non-unionised sector are above the market clearing wage. We find that the average wage for unskilled manual workers in the public, non-unionised sector is £45.25 which is much lower than the average wage in the private, non-unionised sector.

[72]Another source of a positive bias in the coefficient of the supervisor to staff ratio is the substitution of supervisors for workers generated by the increase in the relative wage of workers (Groshen and Krueger 1990). In one of the previous sections we argued that if the 'shirking' rationale holds and if one also controls for differences in effort intensity, we should expect that the problem of substitution is moderated. However, even if substitution occurs in our case and provided that the substitution bias is expected to be positive, this makes our estimate of the trade-off even more compelling.

[73]As suggested above by the OLS equivalence of the MLEs of the parameters of interest showed by Stewart (1983), measurement error is expected to attenuate the estimated coefficient of interest. Thus, based on the evidence of a positive endogeneity bias, we expect that our estimates of the wage-supervision trade-off will be smaller in magnitude in the presense of endogeneity and measurement error. Based on the sample estimates used in our calculations above, we need an estimate of the trade-off of around 0.27 in order that the fall in supervision costs exactly offsets a 1% increase in wages for unskilled manual employees.

[74]As far as the validity and robustness of our results is concerned, the model we use for estimation and inference, as well as interpretation may be inadequate i.e misspecified. In this case the main specification assumptions of the interval regression estimation technique are that: a) the model is linear, b) the error is homoscedastic and normally distributed, and c) there are no omitted variables. Because Stewart (1983) showed that the MLEs of the parameters of the above model are equivalent to the OLS estimators from a regression of the conditional expectation of the latent unobserved variable on exogenous variables, we expect that the violation of the above assumptions will have the same implications as in the standard general linear framework. Thus, non-normality should not be a problem as long as the sample size is sufficiently large, but heteroscedasticity will lead to inefficient estimates and invalid inferences when the standard errors are estimated under the assumption that the model is correct. Similarly, we would expect that omission of relevant variables will lead to biased and inconsistent estimates. In our case we have already suggested that the main causing variable of interest i.e supervision intensity is endogenous, and although we attempt to tackle the endogeneity problem by controlling for confounding variables, the main aim of

6.2 Semi-Skilled

In this subsection we use the same methodology as in the previous section in order to identify the relationship between wages of semi-skilled manual workers and the intensity of supervision across establishments. Results are summarised in tables 4 to 6 (see table section at the end). Table 4 presents estimation of semi-log wage equations for semi-skilled manual employees using the full sample of establishments observations in WIRS 1990.

The main results are similar to the analogous case for unskilled manual employees. In particular, we fail to find any statistically significant estimates of the relationship between wages and supervision, as estimates turn from positive and insignificant to zero, once controls for effort intensity, effort technology and for other motivation devices are gradually introduced in the estimated specification.

The pattern of change in the coefficient of interest across specifications that gradually include 'effort related' controls seems to support the prediction of a positive endogeneity bias, which according to our theoretical analysis of the previous sections seems to be consistent with a 'shirking' efficiency wages rationale. However, a Hausman specification test suggests that the change in the coefficient of the supervisor to staff ratio generated by the inclusion of effort intensity and technology controls as well as controls for the extent at which other practices are used to motivate employees, as merit pay for semi-skilled manual employees and the use of appraisal for pay rises and promotion, is not significant.[75]

our empirical strategy is to identify the direction of the endogeneity bias and use the evidence on the direction of the bias to assess the validity of the main theoretical explanations of the relationship between wages and supervision. Although, endogeneity may be limited after controlling for some confounding factors, it is expected to remain a problem and that is why we expect that our model is misspecified. However, valid inferences can be produced, even under misspecification, as long as inferences are based on estimated asymptotic robust standard errors. In particular, White (1982) showed that under misspecification, the standard Wald and LM tests based on the robust variance covariance matrix of the MLE, have the proper size, are asymptotically equivalent and are asymptotically distributed as chi-squared with degrees of freedom calculated in the traditional fashion. White also showed that the same is not the case for the LR test. Moreover, White showed that the Quasi-MLE (QMLE, the MLE under misspecification), is a consistent estimator of the parameters that minimize the Kullback-Leibler information criterion, and is asymptotically normal. This simply means that the QMLE minimizes our ignorance about the true structure or loosely speaking that consistently estimates the parameters that are the closest to the true parameters (Johnston and Dinardo 1997). Therefore, the above synthesis of seminal results on interval regression and ML estimation, suggests that our inferences are valid, as long as they are based on asymptotic robust standard errors, and that any endogeneity and measurement error bias of our estimates will be minimum. A simple test of the violation of the assumptions of model specification when the dependent variable is grouped is presented by Chesher and Irish (1987).

[75] In general effort related controls are jointly significant but only the dummies for merit pay and appraisal systems for pay rises and promotion are individually significant. The effects of other controls such as size, industry affiliation, ownership and union recognition dummies on semi-skilled employees wages are significant and their signs are consistent with other empirical

Moreover, again we fail to find any evidence that support either the prediction of a negative unobserved employees' quality bias, as predicted by the 'sorting by ability' model or a negative bias because of unobserved differences in union power across establishments.

Although we don't find any strong evidence of an upward omitted variable bias for the full-sample of establishments, the findings may be indicative of an upward bias in the coefficient of interest and that is why we next turn to investigate the wage-supervision relationship for establishments in the private sector in particular, where as argued in the previous section the wage-supervision trade-off may be more pronounced.

Table 5 summarises results from the subsample of all establishments in the private (trading) sector. The findings again are in line with the analogous case of unskilled manual employees, although in this case the estimated coefficient of interest turns from positive and significant to negative but insignificant. Although, the pattern of change in the coefficient of supervision intensity across the specifications of table 6 seem to support the prediction of a positive endogeneity bias, we fail to find any evidence that the estimated coefficient of the supervisor to staff ratio from specification (6) (in which all effort related controls have been included) is systematically larger (in absolute value or more negative) from the analogous coefficient in specification (2) (where no effort related controls have been included).[76]

Furthermore, table 6 summarises results for the subsample of trading sector and non-unionised establishments. In this case, in contrast to our analysis for unskilled manual workers, we fail to find a negative and significant estimate of the relationship between supervision intensity and wages, or even evidence of a significant positive upward bias due to unobserved differences in effort intensity, technology or for the implementation of personnel policies to motivate semi-skilled manual employees. Moreover, in contrast to the analogous case of the previous section, the evidence from this section does not seem to support the conjecture that if the wage-supervision trade-off holds, it is more pronounced in the private and non-unionised sector. However, the pattern of the change in the coefficient of interest across specifications of table 6 as well as the significance of effort related controls is consistent with the prediction of a positive endogeneity bias.

All in all the evidence for the case of semi-skilled manual employees suggest no systematic relationship between wages and supervision (the estimated coefficient tends to zero). However, the

results from the relevant literature.

[76]The Hausman test cannot reject the null that the coefficients of the two specifications are equal. Moreover, note that effort intensity, effort technology and motivation devices controls are jointly and individually significant.

fact that the pattern of change in the coefficient of the supervisor to staff variable seems to be consistent with the prediction of a positive endogeneity bias combined with further concerns for endogeneity bias, measurement error and substitution of supervisors for supervised employees that mask any wage-supervision trade-off that may be in operation, may further suggest that one cannot rule out efficiency wage theory in the case of semi-skilled manual employees, even though we find no significant evidence of a wage-supervision trade-off. Finally, once more we fail to find any evidence in favour of negative bias generated either by unobserved differences in employees' quality[77] or by unobserved differences in union's bargaining power.

6.3 Skilled

In this section we present estimation results from semi-log wage equations for skilled manual workers.[78] The results are summarised in tables 7 to 9.

Table 7 presents results for the full sample of establishments in WIRS 1990. Our findings for skilled manual employees for the full sample of establishments are consistent with the findings for unskilled and semi-skilled in the analogous sample. In particular, the coefficient of interest tends closer to zero once effort related controls are gradually introduced in the estimated specification, although no evidence can be provided that there is significant positive bias generated from unobserved differences in effort related controls.[79] Moreover, on the one hand we fail to find any support to the prediction of a negative 'employees' ability' bias, but on the other hand the evidence suggests that there is a significant negative bias in the coefficient of interest due to unobserved differences in union's bargaining power, a finding which supports our theoretical prediction based on the assumptions that unions negotiate over pay and supervision and 'like' wages but 'dislike' supervision.[80]

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[77] There are other studies with findings that cast doubt to the validity of the prediction of the 'sorting by ability' model of a negative omitted variable bias in the relationship between wages and supervision. For example Neal (1993) presents evidence that jobs in high-wage, primary sector industries supervision is at least as intensive as in jobs in low-wage, secondary sector industries. This finding may further suggest that provided that workers in high-wage, primary sector jobs are of higher quality and are paid higher wages but are not less stringently supervised than low-quality workers in secondary sector jobs.

[78] Based on WIRS 1990 definition, skilled manual workers are manual employees who have received formal training through apprenticeship or its equivalent.

[79] A Hausman specification test cannot reject the null that the coefficient of the supervisor to staff from specification (2) is equal to the same coefficient from specification (6). Note also that effort related controls are jointly significant but only the dummies for all other costs to labour costs share and the dummies for subjective work intensity are individually singificant.

[80] A Hausman test suggests that the coefficient of interest is systematically larger in magnitude in specifications that include dummies for closed shop and for union bargaining over

Furthermore, as in previous sections if we restrict our analysis to the sample of establishments in the trading sector we find some indication of a wage-supervision trade-off, although the estimate of the trade-off is slightly insignificant, as presented in table 8. In this case also the evidence seems to support the prediction of a negative relationship between wages and supervision intensity that may be masked by omitted variable bias, which may be further consistent with an efficiency wage rationale of wage and supervision determination. However, once more we fail to find any evidence that the observed positive bias is significant.

Finally, results for the non-unionised subset of establishments in the trading sector presented in table 9 indicate the same pattern of change in the coefficient of interest across specifications, as for unskilled and semi-skilled but the estimate of the wage-supervision relationship is negative but insignificant. Again, as in the case of semi-skilled manual employees, no evidence can be provided of a significant positive bias in the coefficient of the supervisor to staff ratio.[81]

In general, in this section we fail to find any evidence of a significant relationship (positive or negative) between wages and supervision for skilled manual workers. Moreover, although the change in the coefficient of interest across different specifications which gradually include effort related controls seems consistent with a positive omitted variable bias, we fail to find systematic evidence of a significant upward bias. This finding may be interpreted in terms of the rationale that as higher wages generate also an income and not only an incentive effect on employees' behaviour and as any income effect is expected to be higher for relatively skilled employees that are paid relatively higher wages,[82] it may be the case that the wage has no effect on employees effort as the income effect offsets the incentive effect of the wage.

Finally, we find some support for the theoretical prediction presented in one of the previous section that a negative bias in the coefficient of interest may be the result of unobserved differences in union bargaining power across establishments, but once again we

staffing and working conditions compared to specifications which do not include union power controls. Another interesting finding is that even though estimated effects of other controls as size, industry affiliation etc, have the expected sign the union recognition dummy is insignificant in all estimated specifications, which may suggest that there is no union wage differential for skilled manual workers.

[81]A Hausman test cannot reject the null that the coefficient of supervisor to staff ratio in specification (2) is equal to the same coefficient from specification (6). The effort intensity and effort technology controls as well as controls for personnel policies for motivating skilled manual employees are jointly significant but only the effort intensity controls (all other costs to labour costs share ratio and subjective effort dummies) are individually significant.

[82]Recall that in the case of labour supply, the evidence suggests that the income effect is more likely to more than offset the substitution effect, the higher is the wage/income of the economic agent.

fail to find any evidence that supports a negative employees quality bias in the estimate of the coefficient of supervision intensity.

7   Conclusions

Efficiency wages explanation of involuntary unemployment and other labour market phenomena cannot be ruled out on a priori theoretical grounds, and thus evidence is needed. More importantly, there is no conclusive evidence as far as the validity of efficiency wages is concerned (Manning and Thomas 1997, Autor 2003).

The main empirical question in the field of efficiency wages, is twofold: Is it true that higher wages increase employee's productivity or quality? Given that the latter hypothesis holds, and thus it pays to increase wages; Is it true that employers prefer to pay efficiency wages in order to elicit productivity or enhance quality of employees, instead of using alternative means (bonding or entry fees)?

There is direct evidence on the first empirical question as provided by empirical studies that try to estimate the effects of wages on productivity (Wadwhani and Wall 1991, Konings and Walsh 1994, Levine 1992). There is also indirect evidence, from the wage structure across industries (Krueger and Summers 1988, Kruse 1992), that supports the efficiency wages story. However, on the one hand empirical studies that provide direct evidence suffer from endogeneity and identification problems and on the other hand studies of inter-industry wage differentials do not seem to support efficiency wages because the relationship between industry wage differentials and efficiency wages seems tenuous (Manning and Thomas 1997).

There is another empirical approach in the testing of efficiency wages, which is particularly concerned with the predictions of the 'shirking' and the 'gift-exchange' models of efficiency wages and seems to be relatively neglected in the literature (Manning and Thomas 1997). In particular, both models predict that if the wage is increased, for given effort, monitoring intensity should be relaxed, even though this is done via a different mechanism in each model.

In the 'shirking' model this is the case because the higher wage imposes a penalty to the shirker if caught and being dismissed, whereas in the "gift-exchange model" this occurs because the higher wage creates a climate of cooperation and reciprocity. This prediction of these efficiency wages models provides a way to conduct an indirect test of the effects of wages on productivity which is a necessary condition for the validity of efficiency wages.

Most of the empirical studies that try to estimate the wage-supervision trade-off (Fitzroy and Kraft, 1986, Leonard, 1987, Neal, 1993, Brunnello, 1995) fail to find any conclusive evidence probably

because of endogeneity bias, as the intensity of supervision, is endogenously and simultaneously determined with wages. Moreover, measurement error in the supervision variable exacerbates estimation problems generated by endogeneity.

Another major problem of empirical studies of the wage-supervision trade-off is that they fail to distinguish between alternative theories or explanations of the wage-supervision trade-off (Groshen and Krueger 1990) and therefore any evidence produced by these studies cannot be used to support or dismiss the validity of efficiency wages. Finally, any empirical attempts that address the above problems (Groshen and Krueger, 1990, Krueger, 1991, Rebitzer, 1995) provide evidence that supports only one of the two main empirical questions for efficiency wages and their results cannot be generalised as they focus on particular industries.

In this paper, we present an empirical test of the efficiency wage theory, which is based on testing the prediction of the 'shirking' and 'gift-exchange' models, that in equilibrium, ceteris paribus, higher wages are associated with lower intensity of supervision, using establishment level data from WIRS 1990.

Our identification strategy is based on the estimation of the equation of isoeffort curves derived from the firm's production function, by exploiting variation in supervision intensity generated by variation in supervision costs (the wage of supervisors) across regions and industries. In order to reduce the endogeneity bias arising from omitted variables and the simultaneous determination of wages and supervision intensity, we include controls for omitted variables that according to efficiency wages are correlated with wages and supervision. In this way, we test for efficiency wages by testing whether there is a bias generated by omission of variables that the efficiency wage theory predicts that are correlated with wages and supervision and whether the direction of the omitted variable bias is consistent with efficiency wage theory predictions. The above strategy, under certain conditions, also enables us to sort out alternative explanations of a wage-supervision trade-off. Moreover, we also provide a novel theoretical explanation of a negative relationship between wages and supervision that suggests that a wage-supervision trade-off may be the result of negative bias generated by unobserved differences in trade union's bargaining power across establishments, when wages and supervision are determined by firm-union bargaining and unions 'like' higher wages but 'dislike' stringent supervision. Although our strategy enables us to reduce the bias, it does not eliminate it and thus the endogeneity problem that is widely faced by the majority of studies in the topic is also a problem of this study. Therefore, we our main contribution is to investigate the hypothesis of the wage/supervision trade-off using UK establishment data, in contrast to existing studies in the filed that have been focused on

US data or data from other European countries.

In the case of unskilled manual workers we find evidence of a significant trade-off between wages and supervision which supports the main tenet of efficiency wages that higher wages are positively correlated with employees' productivity. After also testing whether employers pay efficiency wages in order to elicit productive behaviour by employees, by testing whether higher wages 'pay for themselves' we find no evidence that can rule out efficiency wages in favour of alternative motivation devices.

In the case of semi-skilled and skilled manual workers, the evidence suggests that there is no systematic relationship between wages and supervision or that the wage-supervision relationship is negative but insignificant. However, the pattern of results in the case of semi-skilled and skilled manual workers is fairly similar to that of unskilled and is consistent with a positive omitted variable bias predicted by the efficiency wages theory. Moreover, in the case of skilled manual employees we find some evidence of a small negative 'union power' bias.

In conclusion, we find some evidence that suggests that there are may exist valid efficiency wages considerations for unskilled manual employees but not for semi-skilled and skilled manual employees. This finding seems to provide some support to the main tenet of the thesis that efficiency wages may be more relevant for low-wage employees and that is why the efficiency wage theory may be particularly fruitful in explaining observed phenomena from low-wage labour markets.

8   Tables

Table 1: Maximum Likelihood Estimation of Wage Equations for Unskilled Manual Employees (Full Sample) (Dependent variable is the log median wage for the majority gender in the unskilled manual group)

Independent Variable	(1)	(2)	(3)	(4)	(5)	(6)
Supervisors to staff ratio	0.097 (0.073)	0.018 (0.04)	0.007 (0.04)	0.01 (0.048)	0.014 (0.044)	0.006 (0.043)
Dummies for establishment size	Yes	Yes	Yes	Yes	Yes	Yes
Dummy for establishment in manufacturing	0.053 (0.073)	0.05 (0.02)	0.05 (0.02)	0.052 (0.021)	0.051 (0.021)	0.055 (0.022)
Dummy for establishment in trading sector	0.43 (0.032)	0.24 (0.02)	0.22 (0.029)	0.22 (0.029)	0.22 (0.029)	0.22 (0.029)
Dummy for union recognition for manual	0.24 (0.048)	0.12 (0.03)	0.12 (0.039)	0.12 (0.04)	0.12 (0.04)	0.12 (0.04)
Proportion female in unskilled manual		-0.62 (0.03)	-0.62 (0.039)	-0.62 (0.039)	-0.62 (0.031)	-0.62 (0.031)
Proportion part-time in manual		-0.001 (0.001)	-0.002 (0.001)	-0.002 (0.001)	-0.002 (0.001)	-0.002 (0.001)
Dummies for all other costs to labour costs ratio			Yes	Yes	Yes	Yes
Work intensity dummies				Yes	Yes	Yes
Effort Technology controls					Yes	Yes
Controls for other personnel policies						Yes
Weight	-0.031 (0.034)	-0.019 (0.027)	-0.018 (0.027)	-0.018 (0.027)	-0.015 (0.027)	-0.014 (0.027)
Constant	4.3 (0.12)	4.8 (0.1)	4.89 (0.14)	4.96 (0.11)	4.97 (0.17)	4.98 (0.12)
Sample size	1120	1120	1120	1120	1120	1120

Notes: Asymptotic robust standard errors in parentheses. Establishment size dummies include 8 dummies for if number of employees is between 25 and 50, 50 and 100, 100 and 200, 200 and 500, 500 and 1000, 1000 and 2000, 2000 and 5000, 5000 and 10000 respectively. Effort technology controls include a dummy for other benefits for unskilled manual, the proportion of non-redundant dismissed

Table 2: Maximum Likelihood Estimation of Wage Equations for Unskilled Manual Employees (Trading Sector Sample) (Dependent variable is the log median wage for the majority gender in the unskilled manual group)

Independent Variable	(1)	(2)	(3)	(4)	(5)	(6)
Supervisors to staff ratio	0.082 (0.071)	0.021 (0.039)	-0.0015 (0.039)	-0.0007 (0.04)	-0.006 (0.037)	-0.0156 (0.035)
Dummies for establishment size	Yes	Yes	Yes	Yes	Yes	Yes
Dummy for establishment in manufacturing	0.059 (0.025)	-0.049 (0.014)	-0.05 (0.02)	-0.048 (0.02)	-0.047 (0.02)	-0.042 (0.02)
Dummy for union recognition for manual	0.19 (0.051)	0.013 (0.039)	0.021 (0.04)	0.021 (0.039)	0.023 (0.039)	0.024 (0.04)
Proportion female in unskilled manual		-0.31 (0.03)	-0.31 (0.03)	-0.3 (0.03)	-0.3 (0.03)	-0.29 (0.03)
Proportion part-time in manual		-0.65 (0.05)	-0.65 (0.05)	-0.67 (0.05)	-0.68 (0.059)	-0.68 (0.05)
Dummies for all other costs to labour costs ratio			Yes	Yes	Yes	Yes
Work intensity dummies				Yes	Yes	Yes
Effort Technology controls					Yes	Yes
Controls for other personnel policies						Yes
Weight	0.019 (0.041)	0.026 (0.02)	0.03 (0.02)	0.027 (0.026)	0.029 (0.026)	0.026 (0.026)
Constant	4.66 (0.14)	5.06 (0.09)	5.17 (0.17)	5.28 (0.18)	5.27 (0.13)	5.28 (0.13)
Sample size	817	817	817	817	817	817

Notes: Asymptotic robust standard errors in parentheses. Establishment size dummies include 8 dummies for if number of employees is between 25 and 50, 50 and 100, 100 and 200, 200 and 500, 500 and 1000, 1000 and 2000, 2000 and 5000, 5000 and 10000 respectively. Effort technology controls include a dummy for other benefits for unskilled manual, the proportion of non-redundant dismissed employees and the proportion of sanctioned employees due to disciplinary reasons in the previous year. Other personnel policies controls include dummies for merit pay for unskilled manual and for whether all employees are under appraisal for promotion and pay rises. The inclusion of 'union power' controls as dummies for closed shop and for whether recognised unions negotiate over manning/staffing, etc. in (6) results in an estimated coefficient of the supervisor to staff ratio of -0.0149. A generalised Hausman test cannot reject the null that the coefficient of the supervisor to staff ratio in model (6) is the same with or without 'union power' controls, but it can reject the null when the test is about joint inclusion of controls for effort intensity, effort technology and other motivation devices.

Table 3: Maximum Likelihood Estimation of Wage Equations for Unskilled Manual Employees (Trading and Non-Unionised Sector Sample) (Dependent variable is the log median wage for the majority gender in the unskilled manual group)

Independent Variable	(1)	(2)	(3)	(4)	(5)	(6)
Supervisors to staff ratio	0.06 (0.056)	-0.0005 (0.034)	-0.023 (0.034)	-0.028 (0.033)	-0.047 (0.031)	-0.06 (0.03)
Dummies for establishment size	Yes	Yes	Yes	Yes	Yes	Yes
Dummy for establishment in manufacturing	0.2 (0.04)	-0.018 (0.036)	0.02 (0.036)	-0.028 (0.036)	-0.038 (0.037)	-0.011 (0.03)
Proportion female in unskilled manual		-0.034 (0.067)	-0.32 (0.06)	-0.32 (0.06)	-0.29 (0.062)	-0.3 (0.06)
Proportion part-time in manual		-0.62 (0.079)	-0.63 (0.08)	-0.63 (0.078)	-0.66 (0.08)	-0.65 (0.08)
Dummies for all other costs to labour costs ratio			Yes	Yes	Yes	Yes
Work intensity dummies				Yes	Yes	Yes
Effort Technology controls					Yes	Yes
Controls for other personnel policies						Yes
Weight	0.004 (0.05)	0.01 (0.03)	0.007 (0.034)	0.001 (0.033)	0.003 (0.034)	0.009 (0.033)
Constant	4.6 (0.13)	5.01 (0.1)	5.17 (0.17)	5.13 (0.15)	5.12 (0.16)	5.17 (0.16)
Sample size	300	300	300	300	300	300

Notes: Asymptotic robust standard errors in parentheses. Establishment size dummies include 8 dummies for if number of employees is between 25 and 50, 50 and 100, 100 and 200, 200 and 500, 500 and 1000, 1000 and 2000, 2000 and 5000, 5000 and 10000 respectively. Effort technology controls include a dummy for other benefits for unskilled manual, the proportion of non-redundant dismissed employees and the proportion of sanctioned employees due to disciplinary reasons in the previous year. Other personnel policies controls include dummies for merit pay for unskilled manual and for whether all employees are under appraisal for promotion and pay rises. A generalised Hausman test rejects the null that the coefficient of the supervisor to staff ratio in model (6) and in model (2) where no controls

Table 4: Maximum Likelihood Estimation of Wage Equations for Semi-Skilled Manual Employees (Full Sample) (Dependent variable is the log median wage for the majority gender in the semi-skilled manual group)

Independent Variable	(1)	(2)	(3)	(4)	(5)	(6)
Supervisors to staff ratio	0.14 (0.09)	0.039 (0.059)	0.03 (0.057)	0.03 (0.057)	0.011 (0.057)	0.0038 (0.059)
Dummies for establishment size	Yes	Yes	Yes	Yes	Yes	Yes
Dummy for establishment in manufacturing	0.049 (0.023)	0.047 (0.019)	0.05 (0.02)	0.048 (0.02)	0.053 (0.02)	0.053 (0.02)
Dummy for establishment in trading sector	0.29 (0.031)	0.18 (0.027)	0.17 (0.028)	0.17 (0.028)	0.16 (0.029)	0.16 (0.029)
Dummy for union recognition for manual	0.14 (0.05)	0.1 (0.041)	0.09 (0.04)	0.09 (0.04)	0.09 (0.04)	0.09 (0.04)
Proportion female in semi-skilled manual		-0.54 (0.03)	-0.54 (0.031)	-0.54 (0.031)	-0.54 (0.031)	-0.54 (0.031)
Proportion part-time in manual		-0.001 (0.0005)	-0.001 (0.0005)	-0.001 (0.0005)	-0.001 (0.0005)	-0.001 (0.0005)
Dummies for all other costs to labour costs ratio			Yes	Yes	Yes	Yes
Work intensity dummies				Yes	Yes	Yes
Effort Technology controls					Yes	Yes
Controls for other personnel policies						Yes
Weight	-0.047 (0.03)	-0.034 (0.023)	-0.036 (0.023)	-0.034 (0.023)	-0.033 (0.023)	-0.033 (0.023)
Constant	4.72 (0.11)	4.98 (0.089)	4.93 (0.11)	5.04 (0.11)	5.05 (0.17)	5.05 (0.17)
Sample size	908	908	908	908	908	908

Notes: Asymptotic robust standard errors in parentheses. Establishment size dummies include 8 dummies for if number of employees is between 25 and 50, 50 and 100, 100 and 200, 200 and 500, 500 and 1000, 1000 and 2000, 2000 and 5000, 5000 and 10000 respectively. Effort technology controls include a dummy for other benefits for semi-skilled manual, the proportion of non-redundant dismissed employees and the proportion of sanctioned employees due to disciplinary reasons in the previous year. Other personnel policies controls include dummies for merit pay for semi-skilled manual and for whether all employees are under appraisal for promotion and pay rises. The inclusion of 'union power' controls as dummies for closed shop and for whether recognised unions negotiate over manning/staffing, etc. in (6) results in an estimated coefficient of the supervisor to staff ratio of 0.013. A generalised Hausman test cannot reject the null that the coefficient of the supervisor to staff ratio in model (6) is the same with or without 'union power' controls as well as cannot also reject the null when the test is about joint inclusion of controls for effort intensity, effort technology and other motivation devices.

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Table 5: Maximum Likelihood Estimation of Wage Equations for Semi-Skilled Manual Employees (Trading Sector Sample) (Dependent variable is the log median wage for the majority gender in the semi-skilled manual group)

Independent Variable	(1)	(2)	(3)	(4)	(5)	(6)
Supervisors to staff ratio	0.17 (0.08)	-0.034 (0.057)	-0.049 (0.06)	-0.049 (0.059)	-0.06 (0.06)	-0.057 (0.074)
Dummies for establishment size	Yes	Yes	Yes	Yes	Yes	Yes
Dummy for establishment in manufacturing	0.049 (0.02)	0.005 (0.019)	0.004 (0.019)	0.001 (0.019)	0.002 (0.01)	0.005 (0.019)
Dummy for union recognition for manual	0.11 (0.054)	0.06 (0.04)	0.062 (0.04)	0.049 (0.042)	0.051 (0.041)	0.054 (0.04)
Proportion female in semi-skilled manual		-0.46 (0.035)	-0.46 (0.03)	-0.46 (0.03)	-0.46 (0.035)	-0.46 (0.034)
Proportion part-time in manual		-0.4 (0.06)	-0.41 (0.06)	-0.4 (0.06)	-0.41 (0.065)	-0.41 (0.065)
Dummies for all other costs to labour costs ratio			Yes	Yes	Yes	Yes
Work intensity dummies				Yes	Yes	Yes
Effort Technology controls					Yes	Yes
Controls for other personnel policies						Yes
Weight	-0.054 (0.02)	-0.046 (0.024)	-0.05 (0.02)	-0.04 (0.02)	-0.048 (0.024)	-0.046 (0.024)
Constant	5.04 (0.12)	5.24 (0.08)	5.32 (0.09)	5.35 (0.11)	5.55 (0.11)	5.55 (0.11)
Sample size	764	764	764	764	764	764

Notes: Asymptotic robust standard errors in parentheses. Establishment size dummies include 8 dummies for if number of employees is between 25 and 50, 50 and 100, 100 and 200, 200 and 500, 500 and 1000, 1000 and 2000, 2000 and 5000, 5000 and 10000 respectively. Effort technology controls include a dummy for other benefits for semi-skilled manual, the proportion of non-redundant dismissed employees and the proportion of sanctioned employees due to disciplinary reasons in the previous year. Other personnel policies controls include dummies for merit pay for semi-skilled manual and for whether all employees are under appraisal for promotion and pay rises. The inclusion of 'union power' controls as dummies for closed shop and for whether recognised unions negotiate over manning/staffing, etc. in (6) results in an estimated coefficient of the supervisor to staff ratio of -0.053. A generalised Hausman test cannot reject the null that the coefficient of the supervisor to staff ratio in model (6) is the same with or without 'union power' controls as well as cannot also reject the null when the test is about joint inclusion of controls for effort intensity, effort technology and other motivation devices.

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Table 6: Maximum Likelihood Estimation of Wage Equations for Semi-Skilled Manual Employees (Trading and Non-Unionised Sector Sample) (Dependent variable is the log median wage for the majority gender in the semi-skilled manual group)

Independent Variable	(1)	(2)	(3)	(4)	(5)	(6)
Supervisors to staff ratio	0.22 (0.13)	0.067 (0.08)	0.062 (0.064)	0.051 (0.08)	0.071 (0.078)	0.037 (0.08)
Dummies for establishment size	Yes	Yes	Yes	Yes	Yes	Yes
Dummy for establishment in manufacturing	0.18 (0.043)	0.053 (0.038)	0.05 (0.039)	0.047 (0.04)	0.047 (0.04)	0.056 (0.039)
Proportion female in semi-skilled manual		-0.4 (0.06)	-0.39 (-0.06)	-0.4 (0.06)	-0.4 (0.06)	-0.39 (0.065)
Proportion part-time in manual		-0.4 (0.09)	-0.41 (0.09)	-0.41 (0.09)	-0.41 (0.09)	-0.43 (0.096)
Dummies for all other costs to labour costs ratio			Yes	Yes	Yes	Yes
Work intensity dummies				Yes	Yes	Yes
Effort Technology controls					Yes	Yes
Controls for other personnel policies						Yes
Weight	-0.027 (0.047)	-0.04 (0.03)	-0.04 (0.03)	-0.04 (0.033)	-0.04 (0.033)	-0.055 (0.036)
Constant	4.89 (0.15)	5.2 (0.11)	5.4 (0.14)	5.3 (0.15)	5.3 (0.15)	5.47 (0.18)
Sample size	252	252	252	252	252	252

Notes: Asymptotic robust standard errors in parentheses. Establishment size dummies include 8 dummies for if number of employees is between 25 and 50, 50 and 100, 100 and 200, 200 and 500, 500 and 1000, 1000 and 2000, 2000 and 5000, 5000 and 10000 respectively. Effort technology controls include a dummy for other benefits for semi-skilled manual, the proportion of non-redundant dismissed employees and the proportion of sanctioned employees due to disciplinary reasons in the previous year. Other personnel policies controls include dummies for merit pay for semi-skilled manual and for whether all employees are under appraisal for promotion and pay rises. A generalised Hausman test cannot reject the null that the coefficient of the supervisor to staff ratio in model (6) and in model (2) where no controls for effort intensity, effort technology and other motivation devices are included, are equal.

Table 7: Maximum Likelihood Estimation of Wage Equations for Skilled Manual Employees (Full Sample) (Dependent variable is the log median wage for the majority gender in the skilled manual group)

Independent Variable	(1)	(2)	(3)	(4)	(5)	(6)
Supervisors to staff ratio	0.094 (0.13)	0.047 (0.12)	0.036 (0.12)	0.04 (0.12)	0.027 (0.12)	0.033 (0.11)
Dummies for establishment size	Yes	Yes	Yes	Yes	Yes	Yes
Dummy for establishment in manufacturing	0.087 (0.023)	0.077 (0.021)	0.079 (0.021)	0.079 (0.021)	0.08 (0.021)	0.078 (0.021)
Dummy for establishment in trading sector	0.28 (0.028)	0.21 (0.026)	0.21 (0.027)	0.21 (0.027)	0.21 (0.027)	0.19 (0.02)
Dummy for union recognition for manual	0.013 (0.047)	-0.006 (0.043)	-0.006 (0.04)	-0.006 (0.04)	-0.0007 (0.04)	0.001 (0.043)
Proportion female in skilled manual		-0.53 (0.044)	-0.53 (0.044)	-0.53 (0.044)	-0.52 (0.044)	-0.51 (0.044)
Proportion part-time in manual		-0.0045 (0.01)	-0.005 (0.001)	-0.005 (0.001)	-0.005 (0.001)	-0.004 (0.001)
Dummies for all other costs to labour costs ratio			Yes	Yes	Yes	Yes
Work intensity dummies				Yes	Yes	Yes
Effort Technology controls					Yes	Yes
Controls for other personnel policies						Yes
Weight	-0.029 (0.034)	-0.032 (0.029)	-0.034 (0.029)	-0.034 (0.029)	-0.033 (0.029)	-0.036 (0.028)
Constant	4.97 (0.12)	5.11 (0.1)	5.19 (0.19)	5.19 (0.19)	5.19 (0.19)	5.19 (0.18)
Sample size	1087	1087	1087	1087	1087	1087

Notes: Asymptotic robust standard errors in parentheses. Establishment size dummies include 8 dummies for if number of employees is between 25 and 50, 50 and 100, 100 and 200, 200 and 500, 500 and 1000, 1000 and 2000, 2000 and 5000, 5000 and 10000 respectively. Effort technology controls include a dummy for other benefits for skilled manual, the proportion of non-redundant dismissed employees and the proportion of sanctioned employees due to disciplinary reasons in the previous year. Other personnel policies controls include dummies for merit pay for skilled manual and for whether all employees are under appraisal for promotion and pay rises. The inclusion of 'union power' controls as dummies for closed shop and for whether recognised unions negotiate over manning/staffing, etc. in (6) results in an estimated coefficient of the supervisor to staff ratio of 0.05. A generalised Hausman test rejects the null that the coefficient of the supervisor to staff ratio in model (6) is the same with or without 'union power' controls, but it cannot reject the null when the test is about joint inclusion of controls for effort intensity, effort technology and other motivation devices.

Table 8: Maximum Likelihood Estimation of Wage Equations for Skilled Manual Employees (Trading Sector Sample) (Dependent variable is the log median wage for the majority gender in the skilled manual group)

Independent Variable	(1)	(2)	(3)	(4)	(5)	(6)
Supervisors to staff ratio	0.15 (0.17)	-0.1 (0.11)	-0.13 (0.1)	-0.133 (0.11)	-0.083 (0.1)	-0.13 (0.1)
Dummies for establishment size	Yes	Yes	Yes	Yes	Yes	Yes
Dummy for establishment in manufacturing	0.089 (0.024)	0.008 (0.019)	0.013 (0.02)	0.014 (0.02)	0.022 (0.019)	0.02 (0.019)
Dummy for union recognition for manual	-0.003 (0.052)	-0.064 (0.041)	-0.054 (0.041)	-0.051 (0.041)	-0.044 (0.041)	-0.043 (0.041)
Proportion female in skilled manual		-0.37 (0.055)	-0.36 (0.054)	-0.36 (0.054)	-0.34 (0.052)	-0.34 (0.052)
Proportion part-time in manual		-0.62 (0.067)	-0.64 (0.06)	-0.63 (0.065)	-0.62 (0.063)	-0.62 (0.063)
Dummies for all other costs to labour costs ratio			Yes	Yes	Yes	Yes
Work intensity dummies				Yes	Yes	Yes
Effort Technology controls					Yes	Yes
Controls for other personnel policies	-0.003 (0.039)	-0.024 (0.03)	-0.027 (0.03)	-0.026 (0.028)	-0.021 (0.028)	-0.019 (0.028)
Weight	5.24 (0.14)	5.43 (0.11)	5.53 (0.15)	5.64 (0.14)	5.56 (0.14)	5.53 (0.14)
Constant	887	887	887	887	887	887

Notes: Asymptotic robust standard errors in parentheses. Establishment size dummies include 8 dummies for if number of employees is between 25 and 50, 50 and 100, 100 and 200, 200 and 500, 500 and 1000, 1000 and 2000, 2000 and 5000, 5000 and 10000 respectively. Effort technology controls include a dummy for other benefits for skilled manual, the proportion of non-redundant dismissed employees and the proportion of sanctioned employees due to disciplinary reasons in the previous year. Other personnel policies controls include dummies for merit pay for skilled manual and for whether all employees are under appraisal for promotion and pay rises. The inclusion of 'union power' controls as dummies for closed shop and for whether recognised unions negotiate over manning/staffing, etc. in (6) results in an estimated coefficient of the supervisor to staff ratio of -0.1. A generalised Hausman test cannot reject the null that the coefficient of the supervisor to staff ratio in model (6) is the same with or without 'union power' controls, as well as it cannot also reject the null when the test is about inclusion of controls for effort intensity, effort technology and other motivation devices.

Table 9: Maximum Likelihood Estimation of Wage Equations for Skilled Manual Employees (Trading and Non-Unionised Sector Sample) (Dependent variable is the log median wage for the majority gender in the skilled manual group)

Independent Variable	(1)	(2)	(3)	(4)	(5)	(6)
Supervisors to staff ratio	0.52 (0.28)	-0.015 (0.23)	0.01 (0.22)	-0.035 (0.23)	-0.083 (0.23)	-0.075 (0.24)
Dummies for establishment size	Yes	Yes	Yes	Yes	Yes	Yes
Dummy for establishment in manufacturing	0.2 (0.047)	0.052 (0.042)	0.063 (0.041)	0.064 (0.042)	0.065 (0.042)	0.055 (0.042)
Proportion female in skilled manual		-0.31 (0.08)	-0.31 (0.08)	-0.31 (0.08)	-0.3 (0.08)	-0.29 (0.08)
Proportion part-time in manual		-0.67 (0.097)	-0.64 (0.096)	-0.65 (0.09)	-0.64 (0.09)	-0.62 (0.08)
Dummies for all other costs to labour costs ratio			Yes	Yes	Yes	Yes
Work intensity dummies				Yes	Yes	Yes
Effort Technology controls					Yes	Yes
Controls for other personnel policies						Yes
Weight	-0.001 (0.06)	-0.012 (0.046)	-0.024 (0.044)	-0.026 (0.044)	-0.024 (0.043)	-0.026 (0.041)
Constant	5.001 (0.19)	5.26 (0.15)	5.27 (0.21)	5.19 (0.23)	5.23 (0.21)	5.14 (0.21)
Sample size	284	284	284	284	284	284

Notes: Asymptotic robust standard errors in parentheses. Establishment size dummies include 8 dummies for if number of employees is between 25 and 50, 50 and 100, 100 and 200, 200 and 500, 500 and 1000, 1000 and 2000, 2000 and 5000, 5000 and 10000 respectively. Effort technology controls include a dummy for other benefits for skilled manual, the proportion of non-redundant dismissed employees and the proportion of sanctioned employees due to disciplinary reasons in the previous year. Other personnel policies controls include dummies for merit pay for skilled manual and for whether all employees are under appraisal for promotion and pay rises. A generalised Hausman test cannot reject the null that the coefficient of the supervisor to staff ratio in model (6) and in model (2) where no controls for effort intensity, effort technology and other motivation devices are included, are equal.

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