The Trade-Off Between Supervision Cost and Performance Based Pay: Does Gender Matter?*

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Abstract. The study adds to the literature by providing new empirical evidence consistent with efficiency wage theory, and by providing estimates of the average cost of supervising a worker by industry. This research uses the 1996 wave of the NLSY and incorporates estimates of supervision cost computed from industry classifications. We further detect presence of no gender differences neither in risk-averseness nor in productivity gains associated with cost of supervision and performance-based pay. While the findings imply that employers should consider the incentive effects of supervision and performance based pay when constructing pay schemes, there is no need for employers to devote resources to constructing gender-specific payment mechanisms. Our evidence suggests that profit-maximizing firms should treat males and females equally and develop gender-neutral pay schemes.

I. Introduction

Evidence from past studies shows that productivity may increase with greater supervisory intensity (i.e., external supervision) and/or with greater "internal" (or self-) supervision (Leonard, 1987). In the efficiency wage literature internal supervision may take the form of higher wages since higher wages result in higher costs of shirking for workers. Thus, in efficiency wage models a principal can induce agents to provide effort via higher wages or greater monitoring. Several papers have examined the effect of monitoring on wages and have concluded that workers earn more where monitoring is more difficult (e.g., Lindbeck and Snower, 1987; Ewing and Payne, 1999). It has also been found that workers who are employed in jobs that have pay based on performance earn more (Brown, 1990, 1992; Ewing, 1996; Parent, 1999; Booth and Frank, 1999). In these situations, workers who provide more effort are rewarded with higher pay. In the model presented in this paper, monitoring and performance based pay are treated as substitutes in the production process. The principal can buy self-supervision through performance based pay or decrease the likelihood of shirking by devoting resources to external supervision. A profit-maximizing firm will choose the optimal mix of internal-external supervision. This paper presents a simple model where internal and external supervision measures may be substitutes and then empirically tests the model using a new measure of the cost of supervising workers to determine if the evidence supports this claim. Moreover, based on the work of Goldin (1986) and Bulow and Summers (1986), it is often thought that firms may treat males and females differently with regard to wage premium and supervisory intensity. The model in this paper lends itself to testing for the possible presence of gender differences.

A common practice in efficiency wage studies is to use firm size and/or establishment size as a proxy for monitoring cost; however, it is both desirable and more appropriate to use a dollar figure that represents what it really costs a firm to supervise a typical worker. While some studies have attempted to measure supervision intensity

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or cost, none have pinned down a good estimate of this type of supervisory cost (e.g., Evans and Leighton, 1989; Robinson and Wunnava, 1991; Ewing and Payne, 1999). The measure of monitoring cost used in this paper is unique and comes from the 1996 wave of the National Longitudinal Surveys of Youth (NLSY) data set. The NLSY allows for the construction of a new measure of monitoring intensity that is given in dollars. As described below, this paper provides industry level average estimates of what it costs a firm (in dollars) to supervise a typical worker. This variable is then incorporated into the wage regressions along with information on whether or not the worker receives performance based pay. The results indicate that supervision cost and performance based pay are positively related to the wage a worker receives. The evidence also suggests that these two variables are substitutes in the production process (i.e., there is a trade-off between supervision cost and internal supervision). However, contrary, to conventional wisdom, we do not find evidence of any gender differences. This latter finding suggests that, with regards to supervision and performance pay, firms appear to treat males and females similarly.[1] In particular, results are not consistent with the argument that it may be more costly to supervise men than women, nor that women may be more risk averse than men.

II. Incentive plans and increased productivity

Under efficiency wage theory, a wage rate above the going market rate works as a monetary incentive to promote higher levels of effort/productivity and decrease "shirking" on the part of the worker. Thus, worker compensation becomes correlated with performance on-the-job. Incentive payment systems provide the same relationship. Basically, incentive plans tie pay directly to individual or group performance. Although some systems might offer a certain base wage to employees, there still remains a variable element to compensation which hinges upon output (Mitchell et al., 1990, p. 21]. This certain type of plan is designed to accommodate those workers who are at least slightly risk averse and do not like the concept of an entirely variable income stream but who do wish to be rewarded for their own productivity.

According to Mitchell et al. (1990) workers under incentive plans consistently earn higher wages compared to workers who are compensated merely by the hour. Some economists maintain that it is difficult to determine whether firms are receiving higher levels of productivity from workers employed under incentive plans.[2] However, firms in a competitive market must be receiving some form of a return for implementing these types of systems or else they would have to eliminate these plans in order to remain competitive. In their wage survey of workers in 11 different industries, Mitchell et al. (1990) found that employees under incentives enjoyed a wage advantage of 14% over other workers. Moreover, other studies[3] indicate that incentives do tend to motivate workers. When incentives are introduced properly, there is generally a rise of 10–25% in productivity gains. Yet, in some instances, effective incentive plans are difficult to implement. In the situation where employees are awarded bonuses for reaching a set goal, some workers may attempt to keep production norms low in order to keep the goals from being raised. Employees may also choose not to perform other activities in the workplace that are not directly necessary for producing output, such as cleaning up the work area, etc. Therefore incentive plans are most valuable in occupations where employees either work individually or in small groups while the work is stable and does not need constant revision of standards (Mitchell et al., 1990, p. 66).

Overall, incentive plans appear to enhance productivity. Ehrenberg and Bognanno (1990) conducted a study of the 1984 men's PGA tour in which they examined tournaments and tournament-style payment schemes. They discovered that tournaments do have incentive effects in that higher prize levels are positively related to lower golf scores with scores being affected to a greater degree in the later rounds of the tournament. Bognanno and Ehrenberg found some support for the hypothesis that better players tend to be more responsive to financial incentives (p. 1322).

III. Theoretical framework

The model presented here comes from Robinson and Wunnava (1991) and has its origins in Bulow and Summers (1986). The latter paper derives the no-shirking condition for workers in the primary sector under standard assumptions that workers maximize lifetime utility, have dis-utility associated with effort, and may be fired if caught shirking. From Bulow and Summers (1986) wage premium expression, Robinson and Wunnava (1991) develop a simple efficiency wage model. Let y denote output, w the wage paid, p the wage premium (which elicits internal supervision as it raises compensation above the alternative), S the amount of supervision (which provides external supervision), c per unit cost of supervision (it is assumed that supervision is costly in that firms must devote resources to its provision), N the amount of labor, and e denotes work effort. Assuming the output price is normalized to one, then firms maximize the following profit (π) function by choosing N, p, and S:

$$\pi = y - (w + p)N - cS$$

where

$$y = f(N, e) \quad \text{and} \quad e = g(p, S)$$

f and g are assumed to be well-behaved functions in the sense that both increase at decreasing rates in terms of their arguments. Note that g_{pS} may be $<$, $>$, or $= 0$; however, in the case where $g_{pS} < 0$, p and S are substitutes.

As discussed in Robinson and Wunnava (1991), several researchers have argued that $g_p(p, S)$ is larger for males than for females (i.e., the marginal gains in work intensity from increasing wage premia will be larger for males than for females), perhaps due to lesser degree of job attachment by females (Goldin, 1986; Bulow and Summers, 1986). Under these conditions, females are not expected to be as responsive to wage premium as males, and males will have larger wage premium than females for the same effort. Alternatively, if employers perceive females as easier to manage than males, then the cost of supervision will be higher for males. In either case, firms treat males and females differently and, therefore, females will receive more supervision and lower wage premium than males for the same work effort. However, if women seem to be more risk averse than men (Johnson and Powell, 1994; Jianakoplos and Bernasek, 1998; and Senden and Surette, 1998) employers may be inclined to offer higher relative wages to attract women (than men) given earnings uncertainty under performance based pay structure (McGoldrick, 1995).

Accordingly, in terms of the empirical work, supervision cost and performance based pay should be positively related to the wage received. However, the foregoing discussion also suggests that the effect of supervision cost may be larger for males than for females (i.e., it may be more costly to supervise men than women), and there may be a larger impact of performance based pay on wages of females than males (i.e., women may be more risk averse than men). In the next section we discuss our empirical analysis.

IV. Empirical analysis

A. *Data*

The data are from the National Longitudinal Surveys of Youth (NLSY), which has interviewed respondents annually since 1979. The initial wave contained 12,686 individuals between the ages of 14 and 21. The sample consists of those who worked for pay in the year prior to the 1996 wave.

Workers are first assigned to an industry using one digit SIC codes. A total of ten industry classifications (refer to Table I) are used. To construct the supervision cost measure workers are further identified as being either a supervisor or non-supervisor. For each supervisor, the NLSY provides information as to the number of workers they monitor on a daily basis. Each supervisor's hourly wage is then divided by the number of workers he/she monitors. The average of this number, by industry, is computed and used as an estimate of the average cost of supervising a worker for that industry. Table I provides these estimates of average cost of supervision by industry.[4] Table I also presents the proportion of non-supervisory female (male) workers in each industry group. The average hourly cost of supervision ranges from \$2.50 (wholesale and retail – where proportion of males [0.53] is slightly higher than females [0.47]) to \$8.84 (finance, insurance, and real estate – where proportion of females [0.66] is substantially higher than males [0.34]). We also note that construction industry is dominated by males and professional, entertainment and recreational services industry is dominated by females.

TABLE I
Average cost per hour of supervising a worker by industry

Industry	Supervision cost ($)	Proportion female (number)	Proportion male (number)
Wholesale and retail	2.5084	0.47	0.53
	(3.4189)	(74)	(84)
Personal services	4.0419	0.62	0.38
	(6.6706)	(48)	(30)
Agriculture and mining	4.3789	0.32	0.68
	(6.0548)	(7)	(15)
Transportation	4.7983	0.39	0.61
	(4.7843)	(39)	(61)
Manufacturing	4.8488	0.39	0.61
	(5.9479)	(97)	(152)
Construction	5.2665	0.13	0.87
	(4.7378)	(2)	(13)
Public administration	5.6757	0.56	0.44
	(5.3525)	(87)	(68)
Business repair services	5.9177	0.36	0.64
	(7.5692)	(30)	(54)
Professional, entertainment and recreation services			
	6.0333	0.75	0.25
	(6.9869)	(374)	(125)
Finance, insurance, and real estate	8.8421	0.66	0.34
	(11.2813)	(87)	(45)

Notes: Data are from the 1996 wave of the NLSY. Industry is determined using one digit SIC code. Supervision cost is computed based on wages of respondents identified as supervisors and the number of workers that these supervisors supervise on a daily basis (which can take on values of 1, 2, 3, . . . , *n*). The wage of each supervisor is divided by the number of workers supervised by that supervisor to obtain a (supervisor-specific) cost of supervision. For example, if supervisor A earns $n/hour and supervises m workers, then the cost per hour of each worker supervised by A is $(n/m). The industry average of this cost is calculated and used as the cost of supervising (non-supervisor) workers in that industry. Standard deviation is given in parentheses. Proportion female (male) indicates the proportion of non-supervisory workers in that industry that is female (male). The number of females (males) is given in parentheses.

B. *Empirical model(s)*

In order to examine the effects of supervision cost and performance based pay on wages, attention is restricted to the group of non-supervisors. The resulting sample size is 1492. A base log wage (ln *W*) model (equation 1) is proposed for all non-supervisors who are employed full time:[5]

$$\ln W_j = \beta_0 + \alpha_0(female)_j + \beta_1(performance\ pay)_j + \beta_2(supervision\ cost)_j + \beta_3(establishment\ size)_j + \beta_4(performance\ pay \times supervision\ cost)_j + \mathbf{X}\Omega + u_j \quad (1)$$

where *performance pay* is a binary variable (= 1 if the respondent reports earnings are based on piece rate, bonus, commission, or tips; 0 otherwise), *supervision cost* is the average cost of supervising a worker, *supervision cost* × *performance pay* is an interaction term, and *female* is a gender indicator variable (= 1 if the respondent is female and 0 if male). The *establishment size* variable (defined as the actual number of employees at the place where the respondent works) is commonly used to proxy monitoring cost and used in efficiency wage studies.[6] The vector **X** is a set of standard human capital and demographic variables. Given the richness of the NLSY it is possible to construct a measure of work experience that represents actual weeks worked. There are several reasons why a measure of actual experience is preferred to using potential work experience (usually defined as age-education-6). Potential experience may understate the returns to experience because it treats time not working the same as time working. This is particularly troublesome when estimating wages of persons who are more likely to have intermittent labor force participation. The use of both actual experience and tenure at the current firm should capture the total work experience of the respondent. Additionally, we include vectors of occupation controls,[7] which presumably capture much of the heterogeneity in monitoring technology not captured by establishment size. Other variables include controls for marital status, actual number of children in the household, race, education level (as measured by number of years of schooling completed), AFQT score, region, and urban area.[8] Based on our earlier discussion, it is expected that $\beta_1 > 0$ and $\beta_2 > 0$; and a finding of $\beta_4 < 0$ provides evidence that performance based pay and supervision cost are substitutes. Moreover, the existing literature (Booth and Frank, 1999; Evans and Leighton,1989; Ewing and Payne, 1999; Wunnava and Ewing, 1999) suggests that β_3 should be greater than zero.

Since previous research suggests that gender differences in supervision cost and risk aversion may exist, equation 1 is augmented with a set of gender interaction terms as specified in equation 2:

$$\begin{aligned}\ln W_j = {} & \beta_0 + \alpha_0(\mathit{female})_j + \\ & \beta_1(\mathit{performance\ pay})_j + \\ & \alpha_1(\mathit{female} \times \mathit{performance\ pay})_j + \\ & \beta_2(\mathit{supervision\ cost})_j + \\ & \alpha_2(\mathit{female} \times \mathit{supervision\ cost})_j + \\ & \beta_3(\mathit{establishment\ size})_j + \\ & \alpha_3(\mathit{female} \times \mathit{establishment\ size})_j + \\ & \beta_4(\mathit{performance\ pay} \times \\ & \mathit{supervision\ cost})_j + \\ & \alpha_4(\mathit{female} \times \mathit{performance\ pay} \times \\ & \mathit{supervision\ cost})_j + \mathbf{X}\Omega + u_j\end{aligned}$$

C. *Regression results*

Table II presents variable means and summary regression results of the log wage models specified in equation 1 (Panel A), and equation 2 (Panel B). Panel A indicates that males enjoy 16.43% wage premium, and workers whose pay is based on performance earn about 8.9 percent[9] more than otherwise identical workers. It is also found that an increase in supervision cost is associated with higher worker pay,[10] ceteris paribus. These two outcomes are in accord with the predictions of efficiency wage models – workers will earn higher wages at firms where monitoring is more costly and firms can buy internal supervision through the use of performance based pay. A particularly interesting finding is that the interaction term (*performance pay* × *supervision cost*) is negative and significant at the $p = 0.03$ level. The latter finding may be interpreted as evidence consistent with the notion that performance based pay (i.e., internal supervision) and supervision cost (i.e., external supervision) are substitutes in the production process. Thus, firms will choose an optimal mix of internal-external supervision. Note also that the above findings hold while controlling for *establishment size*, which is found to be positively associated with the wage paid, consistent with what is commonly found elsewhere in the literature.

The results reported in Panel B provide information regarding possible gender differences. The coefficients of *performance pay*, *supervision cost*, and *establishment size* for the comparison group (i.e., males) have the anticipated signs and are indeed statistically significant. The estimated coefficient for the interaction term *performance pay* × *supervision cost* also has the expected sign and is marginally significant. Qualitatively, the signs of the estimated coefficients on the *female* indicator variable and the corresponding interactions with *performance pay*, *supervision cost*, *establishment size*, and *performance pay* × *supervision cost* are also in agreement with the theoretical predictions based on previous research.[11] One could note from our complex model 2 that the magnitude of estimated male wage premium, performance based wage premium, and impact of cost of supervision on wages[12] is similar to one reported in our simple model 1. This further provides evidence that the estimates reported in this paper are indeed robust. Our interaction model 2 further would enable us to detect possible gender differences regarding the trade-off between supervision cost and performance based pay. It is logical to assume that a profit-maximizing firm

TABLE II
Summary of results (Dependent variable is ln $W \equiv$ natural log of hourly wage)

A. *Equation 1 Results*

	Coefficient	*t*-stat.	$P > \|t\|$	Mean
female	–0.1643396	–7.224	0.000	0.493
performance pay	0.2623714	3.059	0.002	0.186
supervision cost	0.0318522	3.825	0.000	5.190
establishment size	0.0000148	3.245	0.001	572.810
performance pay × supervision cost	–0.0339679	–2.143	0.032	0.963

$F(29, 1462) = 41.60$
Prob > F = 0.0000
Adj R-squared = 0.4412

B. *Equation 2 Results*

	Coefficient	*t*-stat.	$P > \|t\|$	Mean
female	–0.1184591	–1.329	0.184	0.493
performance pay	0.2428226	2.020	0.044	0.186
female × performance pay	0.0669132	0.385	0.701	0.079
supervision cost	0.0373740	2.884	0.004	5.190
female × supervision cost	–0.0092290	–0.558	0.577	2.658
establishment size	0.0000224	2.734	0.006	572.810
female × establishment size	–0.0000112	–1.156	0.248	332.650
performance pay × supervision cost	–0.0340101	–1.488	0.137	0.963
female × performance pay × supervision cost	–0.0043000	–0.135	0.893	0.422

$F(29, 1462) = 36.60$
Prob > F = 0.0000
Adj R-squared = 0.4407

Notes: Data are from the 1996 wave of the NLSY. Number of observations is 1492. The mean of the dependent variable is 2.438. Control variables for workers include education, tenure (also square term), actual experience (also square term), percentile score on AFQT, occupation, region of country, urban residence, union, marital status, number of children, and race. Full results can be obtained upon request.

will set the ratio of marginal benefits of wage premia (in terms of effort) equal to the marginal benefits of supervision to the costs of supervision. Thus, generally speaking, one would expect that increasing supervision costs would lead to higher wage premia. If there is a difference between males and females in either their responsiveness to wage premia or to supervision, the trade-off will occur at different rates. However, due to lack of insignificant female interaction coefficients, it appears that gender differences in performance based pay and supervision cost may not exist. Specifically, our finding of lack of gender differences of impact of supervisory intensity (captured by cost of supervision) is contrary to previous research of Goldin (1986) and Bulow and Summers (1986).

Interestingly, the reported results in Panel B do not provide support to the commonly held belief that women may be more risk averse than men.[13] In other words, women do not appear to be any different than men in terms of preferring a steady flow of earnings more than an uncertain flow of higher expected earnings, the latter of which is a common feature of performance based pay schemes.

V. Conclusion

This study adds to the literature by providing new empirical evidence on the existence of the wage effects of performance based pay and the cost of worker supervision. The predictions are consistent with those from efficiency wage theory. Unlike other studies in this area, this research uses the 1996 wave of the NLSY and incorporates estimates of average supervision cost computed from industry classifications. Consistent with previous research, we find that wages are positively related to performance based pay. We also find that higher pay is associated with greater cost of supervision. However, in contrast to some widely held beliefs, our results do not support the hypothesis that males are more costly to supervise than females nor that females are more risk averse than males. This paper also documents a new finding, in particular, that internal and external supervision measures appear to be substitutes in the production process.

We find no evidence of gender differences in productivity gains associated with performance based pay and cost of supervision. While the findings imply that employers should consider the incentive effects of supervision and performance based pay when constructing pay schemes, there is no need for employers to devote resources to constructing gender-specific payment mechanisms. Our evidence suggests that profit-maximizing firms should treat males and females equally and develop gender-neutral pay schemes unlike the recommendations of Goldin (1986) and Bulow and Summers (1986), who argue for intense supervision for females relative to males in eliciting effort. On the other hand, our results are similar to the findings of Booth and Frank (1999) and provide new insight into the trade-off between supervision and performance-based pay.

Notes

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1 This concurs with the contention of Booth and Frank (1999).

2 Parent (1999) concludes that the wage effect of performance based pay, as measured by piece rates, stems from two sources: selection and incentives.

3 See for example, Seiler (1984) and Lazear (2000a, b).

4 The *actual* wage of a respondent's supervisor is not given in the NLSY. Due to this data constraint we devised an alternative supervisory cost variable as explained above.

5 The loglin nature of the earnings model(s) specified is within the framework of seminal works of Mincer (1974), and Heckman and Polachek (1974). We employed OLS for estimation, as none our diagnostic test(s) indicated any violations of classical linear regression model.

6 For more on the use of employer size in the efficiency wage literature see Ewing and Payne (1999).

7 The industry dummies have not been include in the empirical specification to alleviate the problem of multicollinearity given our derivation of industry specific average cost of supervising a worker included in the model.

8 Sample characteristics and estimated regression coefficients of variables in the vector 'X' can be obtained up on a request.

9 $[\partial \ln W/(\partial \textit{performance pay}] = \beta_1 + \beta_4(\textit{supervision cost})]$ evaluated at the sample mean of supervision cost = [0.2623716 – 0.034 (5.19)] = 0.089.

10 $[(\ln W/(\partial \textit{supervision cost}] = \beta_2 + \beta_4(\textit{performance pay})]$ evaluated at the sample mean of supervision cost = [0.0318522 – 0.034 (0.186)] = 0.026. A dollar increase in average cost of supervision may result in 2.6% increase in wages.

11 However, these variables are collectively significant. A joint F-test of the null hypothesis that there are no differences between males and females in the estimated model, that is, H_0: $\alpha_0 = \alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = 0$, yielded an observed F-value (5, 1458) = 10.96 with corresponding p-value = 0.00.

12 $[(\ln W/\partial \textit{female}] = \alpha_0 + \alpha_1(\textit{performance pay}) + \alpha_2(\textit{supervision cost}) + \alpha_3(\textit{establishment size}) + \alpha_4(\textit{performance pay} \times \textit{supervision cost})]$ evaluated at the sample mean values = [–0.1184591 + 0.0663192 (0.186) – 0.009229 (5.190) – 0.0000112 (572.81) – 0.0043 (0.963)] = –0.164468;

$[(\ln W/\partial \textit{performance pay}] = \beta_1 + \alpha_1(\textit{female}) + \beta_4(\textit{supervision cost}) + \alpha_4(\textit{female} \times \textit{supervision cost})]$ evaluated at the sample mean values = [0.2428226 + 0.0663192 (0.493) – 0.0340101 (5.190) – 0.0043 (2.658)] = 0.0875;

$[(\ln W/\partial/\partial \textit{supervision cost}] = \beta_2 + \alpha_2(\textit{female}) + \alpha_2(\textit{performance pay}) + \alpha_4(\textit{female} \times \textit{performance pay})]$ evaluated at the sample mean values = [0.037374 + 0.009229 (0.493) – 0.0340101 (0.186) – 0.0043 (0.079)] = 0.026.

13 McGoldrick (1995) concluded that women tend to receive higher compensating wages for uncertainty than their male counterparts.

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