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Efficiency Wages with Endogenous Monitoring

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Abstract

In the standard efficiency wage model, the monitoring level chosen by firms is exogenous and observable. In this paper, the level of monitoring is endogenized—chosen by firms and unobserved by workers. As a result, firms have an incentive to decrease the monitoring of employees for any given beliefs among workers about the chosen level of monitoring. We show that sufficiently patient firms are able to retain some control over the monitoring level. We also show that high-tech firms monitor their workers more and demand a higher level of effort than do low-tech firms.

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1 INTRODUCTION

The dual-labor-market theory (Bullow and Summers 1986; Becker and Stigler 1974; and others) explains the variance in workers' wages and benefits in various sectors of the economy. This theory differs from the human-capital theory (Becker 2009; and others) by assuming that workers are identical and that the discrepancy traces to excess demand for positions in the primary sector. One difference between the primary and the secondary sector is firms' ability to observe the amount of effort exerted by workers. Firms that do not observe the amount of effort exerted by their employees pay their employees a wage that is higher than their alternative or efficiency wage.[1]

The existing efficiency-wage models assume that firms cannot perfectly observe the amount of effort exerted by each worker but that each worker observes the amount of monitoring chosen by each firm. We are not aware of empirical evidence that supports this assumption. In the current paper, we ask how the firm chooses its level of employee monitoring assuming that workers do not perfectly observe this level. We motivate our model by considering several examples. The first concerns the actual level of monitoring that workers do not observe because it is applied via closed-circuit television (CCTV) systems. Such systems are prevalent today among many firms of different sizes. Although managers may access these systems remotely to supervise their employees' actions, in practice they do not do so continually and workers do not observe whether they are monitored or not and for how long. A second example of the actual level of unobserved monitoring is "mystery shopping," in which firms hire workers who pose as customers and monitor the quality of customer service by other employees of the firm. The supervised employees are unaware of these mystery shoppers' existence, let alone their identity. We assume, however, that employees are aware of "standard" monitoring in the form of an immediate supervisor, but not necessarily aware of these additional monitoring measures.

In our model, firms decide what is the expected monitoring level, which represents the expected probability of being caught of a random shirking worker. In that case, an

[1]Previous papers that analyze efficiency wages include Becker and Stigler (1974), Shapiro and Stiglitz (1984), Bullow and Summers (1986), Fong and Li (2012) and Ke, Lin, and Powell (2018). Empirical papers include Blackburn and Neumark (1992), Krueger and Summers (1988), and Lazear, Shaw, and Stanton (2016).

individual worker cannot use his probability of being monitored to perfectly estimate (or form perfect estimates) of being monitored during the next period; he can only form expectations regarding that probability.

2 THE MODEL

The economy consists of a large population of infinitely lived individuals and firms. All individuals have identical preferences, gain utility from consumption, and suffer disutility by exerting effort. There are two types of firms: low- and high-technology (low-tech and high-tech, respectively). Low-tech firms enter freely; following Zábojník (2012), we assume, however, that the number of high-tech firms is fixed, so that not all workers can find employment with them. High-tech firms enjoy market power in their product markets for several possible reasons such as superior (and protected) technology, scale economies, and barriers to entry.

At the beginning of every period, each firm announces wage rate w and requested amount of effort e, and chooses an amount of monitoring q that its workers cannot observe, expressed in terms of the probability of detecting shirking on the part of each worker. As in the standard efficiency wage model, the firm's wage policy consists of the wage level and the firing of any worker who is found shirking. The wage of a worker who is not monitored, or who is monitored and is found to be making an effort, is not changed. Workers observe the probability of being monitored only at the end of each period.

Time in the model is continuous. The instantaneous utility function is given by $u = w - c(e)$, where w denotes the wage rate, e denotes the exerted amount of effort and $c(e)$ the disutility from exerting an effort, and we assume that $c'(e) > 0, c''(e) > 0$.[2]

Each firm employs either one or zero workers. The production function of firm j is given by $E_j e$, where e denotes the effort exerted by the firm's worker and E_j denotes the firm's productivity parameter, which can be high ($E = E_H$) or low ($E = E_L$), $E_H > E_L > 0$. We refer to firms with E_L (E_H) as low- (high-) tech firms. As discussed below, we make further assumptions about the differences between E_H and E_L in order to make the analyzed case more interesting. These assumptions are discussed in the proof

[2] We assume that individuals cannot borrow or lend; hence, the wage equals consumption in each period.

Proposition 1.

At the beginning of each period, firms choose amount of monitoring q, equal to the probability of a shirking worker being detected. We further assume that the amount of monitoring is observable by workers only at the end of each period and not during the period. To be specific, the amount of monitoring becomes observable at the end of fixed-length intervals (t=1,2,3...), which we term "the end of the period." The cost of monitoring (which is the same for both types of firms) is denoted by $z(q)$ and we assume that $z'(q) > 0, z''(q) > 0$. We also assume a minimum level of monitoring by firms, $q_{min} > 0$, which is observable; i.e., if a firm chooses a lower amount than q_{min} in a given period, the worker observes it during the period and not only at the end of the period.[3] This is the case, for example, if the employee's immediate supervisor monitors his actions with a given probability q_{min}, and the worker observes whether the supervisor is present and for how long in a given period. The minimal level of monitoring q_{min} is similar to the exogenous and observable level of monitoring in Shapiro and Stiglitz (1984), and many other papers, e.g. Bullow and Summers (1986).

Jobs may also end naturally at probability b per unit of time, due to relocation and for other reasons.[4] We do not discuss search friction and choose to focus on the equilibrium.[5] In an equilibrium with homogeneous workers, any unemployed worker can find a job at any firm with the same probability, with the flows in and out of equilibrium being equal to each other. We assume that $b, z(q)$ and q_{min} are the same in all firms.[6] The price of the good produced by both types of firms is normalized to 1.

We present two setups. In the first, firms cannot commit to the monitoring level chosen in the current period. In the second, we discuss the conditions that allow firms to commit to a given monitoring level in the current period.

[3] We can show that if $q_{min} = 0$, then workers have no incentive to exert a positive amount of effort.

[4] If the market observes why a given worker has been fired or if $b = 0$, it will be possible to trivially obtain an equilibrium without shirking due to the worker's "reputation loss."

[5] See Burdet and Mortensen (1998) for an analysis of search friction in an economy with heterogeneous firms.

[6] Firms of different sizes may have different monitoring costs (Bulow and Summers, 1986). To reduce the length of this paper, we do not discuss this case.

3 EQUILIBRIUM

We use the Shapiro and Stiglitz (1984) setup. $V^{SL}\left(V^{SH}\right)$ denotes the expected lifetime utility of a shirking worker employed by a low- (high-) tech firm; $V^{NL}\left(V^{NH}\right)$ is the expected lifetime utility of a non-shirker employed by a low- (high-) tech firm; and V^U is the expected lifetime utility of an unemployed individual. Shapiro and Stiglitz (1984) show that $rV^{SL} = w_i + (b+q)(V^U - V^{SL})$, $rV^{SH} = w_i + (b+q)(V^U - V^{SH})$, $rV^{SL} = w_i - c(e_i) + b(V^U - V^{SL})$ and $rV^{NH} = w_i - c(e_i) + b(V^U - V^{NH})$, where r denotes the interest rate and V^U is calculated in Appendix B.[7] Individuals employed by different firms (low-tech and high-tech) may have different wage rates and exert different amounts of effort. The above asset equations are the same for employed workers at both types of firms, as in Shapiro and Stiglitz (1984), and adding two types of firms does not change this. However, V^U, the expected lifetime utility of an unemployed individual, is a function of unemployment benefits and the ratio of low- to high-tech firms.

Workers will choose not to shirk only if $V^{NL} \geq V^{SL}$ and $V^{NH} \geq V^{SH}$, and we can show that the minimum wage rate w that causes workers to exert an amount of effort e is given by

$$w \geq rV^U + \frac{c(e)(r+b+q)}{q} \tag{1}$$

This represents the incentive compatibility (IC) constraint. Workers will choose to participate in the market as long as $V^{NL}, V^{NH} \geq V^U$ (the participation constraint). Although we do not have a closed-form solution to the participation constraint, we assume that it holds.

The efficient amount of effort that firm j demands is given by $E_j - c'(e) = 0$. Hence, the efficient amount of effort differs among firms. The instantaneous profits of a firm of type j that demands amount of effort e_j, pays wage w_j, and chooses amount of monitoring q_j are given by $E_j e_j - w_j - z(q_j)$.

[7] We assume, following Shapiro and Stiglitz (1984), that individuals maximize their expected lifetime utility W, which equals $W = E\int_0^\infty (w - c(e))exp^{-rt}dt$.

We start by discussing an economy without a commitment. Recall that the only incentive to choose a higher amount of monitoring than q_{min} is a commitment to a higher monitoring level in future periods because workers do not observe the amount of monitoring during the current period. Also recall that if the firm chooses a lower amount of monitoring than q_{min}, workers will observe this and as a result will exert no effort—in which case the firm will produce nothing. Hence, if the firm cannot commit to its monitoring level, both types of firms choose q_{min}.

Under the free entry assumption, the wage rate and amount of effort at low-tech firms are those that maximize the utility of workers under the IC constraint and the zero profits condition. Wages at high-tech firms induce workers to choose the amount of effort that maximizes the firms' profits, which in turn are positive. The intuition behind the last observation is that the number of high-tech firms is given and that such firms can make positive profits by offering their workers the same wage and demanding the same low amount of effort as do low-tech firms do. Note also that if high-tech firms provide a lower utility level than do low-tech firms, workers will not join high-tech firms in equilibrium or low-tech firms can increase their profits by lowering wages.

Proofs of the following propositions are given in Appendix A. First, we discuss the more trivial case, resulting directly from the IC constraints. This is necessary to lay ground for the subsequent and more interesting cases.

Proposition 1

When firms cannot commit to a given monitoring level, then

i) Low-tech firms demand the efficient amount of effort if $E_L e^{opL} - z(q_{min}) \geq rV^U + \frac{c(e^{opL})(r+b+q_{min})}{q}$, or a sub-efficient amount of effort if $E_L e^{opL} - z(q_{min}) < rV^U + \frac{c(e^{opL})(r+b+q_{min})}{q_{min}}$, where e^{opL} denotes the efficient level of effort exerted by employees of low-tech firms, calculated above.

ii) High-tech firms demand a sub-efficient amount of effort.

iii) Employees of high-tech firms enjoy higher wages and exert more effort than do employees of low-tech firms.

We denote by e_{cL} (e_{cH}) the amount of effort demanded by low- (high-) tech firms that cannot commit, by w_{cL} (w_{cH}) the wage that these firms pay, and by π_{cH} the total lifetime profits of the high-tech firms (recall that low-tech firms make zero profits) when firms cannot commit.

We now turn to the conditions that allow firms to commit to a given monitoring level q, such that $q > q_{min}$. For the rest of this paper, we assume that both e_{cL} and e_{cH} are below the efficient amount of effort; otherwise, there is no room for a commitment. A firm's commitment is credible only if abrogating it lowers its profit. We assume that if the firm deviates and does not actually monitor at q, workers will believe that the firm has chosen q_{min} from that point on (Baker, Gibbons, and Murphy, 1994; Zábojník, 2012).

A firm that commits makes a positive profit, while a new firm either has no ability to commit or can commit and make the same positive profits as would an incumbent firm. For the rest of the paper, we assume that new firms do not have the ability to commit. Note that if a new firm can commit, it will make a positive profit because its employees believe that it has chosen a higher amount of monitoring than q_{min}. In such a case, firms will enter the market, exit after one period, and re-open.

We start by discussing low-tech firms. If a firm chooses the equilibrium amount of monitoring (calculated below), q_{eL}, while workers exert the equilibrium amount of effort (calculated below), e_{eL} and are paid w_{eL}, then its instantaneous profits are $E_L e_{eL} - w_{eL} - z(q_{eL})$ and its lifetime profits are $\int_0^\infty [E_L e_{eL} - w_{eL} - z(q_{eL})] exp^{-rt} dt$. If the IC constraint is binding, then we obtain that the instantaneous profits of each firm are

$$E_L e_{eL} - (rV^U + \frac{c(e_{eL})(r+b+q)}{q}) - z(q). \tag{2}$$

However, if the firm deviates and chooses $q = q_{min}$ in the current period, then its instantaneous profits will be $E_L e_{eL} - w_{eL} - z(q_{min})$. Its profits until the end of the period, when the deviation becomes observable, are $\int_0^1 (E_L e_{eL} - w_{eL} - z(q_{min})) exp^{-rt} dt$, because workers choose the equilibrium amount of effort and are paid the equilibrium wage in the current period. The firm's future profits are $\int_1^\infty (E_L e_{cL} - w_{cL} - z(q_{min})) exp^{-rt} dt$, as shown in Proposition 1. These profits equal 0 due to the free-entry assumption.

A low-tech firm can commit only if

$$\int_0^1 (E_L e_{eL} - w_{eL} - z(q_{min})) exp^{-rt} dt \;\; < \;\; \int_0^\infty [E_L e_{eL} - w_{eL} - z(q_{eL})] exp^{-rt} dt, \tag{3}$$

where the left-hand side (LHS) denotes the profits from choosing q_{min} during the first period (when worker choose e_{eL}) and moving to an equilibrium in which workers choose e_{cL} and are paid w_{cL}. The amount of monitoring equals q_{min} in each future period, as in Proposition 1, and firms make zero profit in future periods.

Proposition 2

There exists an interest rate r^* such that:

i) If $r < r^*$ a low-tech firm can commit toward to a given monitoring level and choose a requested amount of effort, e_{eL}, pay wage w_{eL} and choose an amount of monitoring of q_{eL} such that e_{eL}, w_{eL} and q_{eL} are given by the FOCs of Equation (2).

ii) The amount of exerted effort in a low-tech firm e_{eL} is suboptimal.

iii) If $r > r^*$ the firm cannot commit toward a given monitoring level and chooses e_{cL} and w_{cL} while making 0 profits.

Turning to a discussion of high-tech firms and denoting by q_{eH} the equilibrium amount of monitoring (calculated below) chosen by high-tech firms, by e_{eH} the equilibrium amount of effort chosen by workers employed by those firms, by w_{eH} the workers' wage rate. Such a firm maximizes:

$$E_H e_{eH} - (rV^U + \frac{c(e_{eH})(r+b+q)}{q} - z(q_{eH}) \qquad (4)$$

Proposition 3

There exists an interest rate r^{**} such that:

i) The amount of effort exerted in high-tech firms is lower than the optimal amount and higher than the amount chosen by low-tech firms.

ii) If $r < r^{**}$, the firm can commit to a given monitoring level and demand amount of effort e_{eH}, pay wage w_{eH} , and choose amount of monitoring of q_{eH} , such that e_{eH}, w_{eH} and q_{eH} are given by the FOCs of Equation (4).

iii) If $r > r^{**}$ the firm cannot commit toward a given monitoring level and chooses e_{cH} and w_{cH} while making profits of π_{cH}.

Building on the above propositions, we can provide some comparisons of the resulting variables. Using Equation (3) and its high-tech firms counterpart, we can show that $r^* < r^{**}$. Using Equation (2) and its high-tech firms counterpart, we can show that

$e_{eH} > e_{eL}$ and $q_{eH} > q_{eL}$. From Equation (1) we obtain that a higher requested amount of effort increases the worker's wage while a higher amount of monitoring reduces that wage.

The intuition is the following: If firms choose an amount of monitoring that is unobservable by their workers during the current period, they will have an incentive to lower the level of monitoring that they choose for any beliefs that workers may have regarding this level. Choosing a low amount of monitoring during this period, however, lowers the amount of monitoring that workers will expect to face in future periods. In this case, if the firm wants to induce its workers to exert an effort even when they expect less monitoring, it has to pay them a higher wage and its future profits will decrease. In Propositions 2 and 3, we show that a higher interest rate decreases the cost of choosing less monitoring because it reduces the present value of future wages. Comparing the level of monitoring chosen by high- and low-tech firms, we show that high-tech firms can commit to a given level of monitoring at a lower interest rate because their opportunity cost in terms of lost future profits due to the decrease in monitoring is higher.

4 DISCUSSION AND CONCLUSION

In this paper, we provide a new explanation for the dual-labor-market theory. The theory shows that the wage of similar workers differs in a competitive equilibrium among firms. Above we demonstrated conditions that allow firms to commit to a given level of monitoring and showed that the wages of similar workers, as well as amount of effort that they exert, differ across firms that commit to different levels of monitoring.

Another contribution of this paper is its comparison of the levels of monitoring chosen by high- and low-tech firms. Thus; we showed that high-tech firms can commit to a given level of monitoring at a lower interest rate because their future profits are higher and their present value is lower than that of low-tech firms. This also explains the higher wages that high-tech firms offer their workers. The heterogeneity of firms and the resulting industrial organization are the factors that allow (some) firms to make a sustainable commitment to monitoring and to pay higher wages.

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APPENDIX A

Proof of Proposition 1

Low-tech firms maximize their profits subject to their workers' incentive compatibility (IC) constraint. It is equivalent to maximizing their instantaneous profits, with respect to e and w. Hence,

$max\ E_L e - z(q) - w$

$s.t\ w \geq rV^U + \frac{c(e)(r+b+q)}{q}$

for $q = q_{min}$.

Recall that firms make zero profits under the free entry assumption.

We obtain two cases:

In the first case, the IC constraint does not bind, the profit of the firm is $E_L e - z(q) - w$ and as a result of free entry, $E_L e - z(q) = w$. Workers' utility is maximized due to the free entry assumption (note that if workers' utility is not maximized then new firms will enter the market) and the profit is: $E_L e - z(q) - c(e)$.This case is obtained when $E_L e^{opL} - z(q) \geq rV^U + \frac{c(e^{opL})(r+b+q)}{q}$,In other words, the output produced by a worker that chooses the optimal amount of effort is high enough such that the IC constraint does not bind (or exactly binds).

In the second case,

$$E_L e^{opL} - z(q) < rV^U + \frac{c(e^{opL})(r+b+q)}{q} \tag{5}$$

Note that if Equation (5) holds, then the output of a worker employed by a low-tech firm is lower than the wage the firm has to pay the worker in order for him to exert the optimal amount of effort, corresponding to q_{min}. In that case, the firm cannot offer the worker a wage that makes him exert the optimal amount of effort while making a non-negative profit. This proves (i).

Also, the workers' utility is lower than in the first case (since in this case we maximize subject to one more constraint). When the IC constraint binds we maximize the following function with respect to e: $rV^U + \frac{c(e)(r+b+q)}{q} - c(e)$, the worker's wage (which is given by the IC constraint) minus his cost of exerting an effort. The derivative with respect to

e yields $\frac{c'(e)(r+b)}{q}$ which is an increasing function of e. Hence, the workers' utility is an increasing function of effort and workers enjoy a lower utility level when the IC binds (since the workers' utility diminishes with effort and they exert less effort).

High-tech firms maximize their lifetime profits with respect to e, which is equivalent to maximizing their instantaneous profits, π:

$max\ \pi = E_H e - w - z(q)$

$s.t\ w \geq rV^U + \frac{c(e)(r+b+q)}{q}$

for $q = q_{min}$.

Note that the IC constraint binds (otherwise, the firm can decrease its worker's wage and increase its profits). One difference between low-tech and high-tech firms is that the first maximize workers' utility subject to the zero profit condition, while the latter maximize their profits subject to providing their workers the equilibrium utility level. In other words, the IC constraint always binds for high-tech firms as discussed below.

We obtain

$$\pi = E_H e - (rV^U + \frac{c(e)(r+b+q)}{q}) - z(q_{min}) \tag{6}$$

where the first expression represents the firm's revenues, the second one represents the wage paid and the last one represents the cost of monitoring.

The first order condition (FOC) of Equation (6) with respect to e yields $E_H - \frac{c'(e)(r+b+q)}{q} = 0$, while efficiency requires $E_H - c'(e) = 0$. Hence, firms require a lower than optimal level of effort, since rearranging the FOC yields

$$E_H - \frac{c'(e)(r+b+q)}{q} = E_H - c'(e)(1 + \frac{(r+b)}{q}). \tag{7}$$

This proves (ii).

We turn to discuss the third part of the proposition. Due to the free entry assumption, low-tech firms make zero profits and the utility level of workers employed by such firms is the lowest utility level a worker can achieve, meaning that high-tech firms must offer at least the same utility level.

If low-tech firms require the efficient amount of effort when the IC constraint does not bind, it must be the case that high-tech firms request a higher amount of effort, since for them the IC constraint always binds and a worker employed by such a firm enjoys a utility level which is equal or higher to the utility level of a worker employed by a low-tech firm. Otherwise, new low-tech firms would enter the market. By the same logic, if low-tech firms require less than the efficient amount of effort (when the IC constraint does bind), high-tech firms will require at least the same amount of effort, and the workers' utility level is an increasing function of the requested effort.[8] This proves (iii).

■

Proof of Proposition 2

Low-tech firms maximize their instantaneous profits:

$E_L e - w - z(q)$

s.t

$$\int_0^1 (E_L e_{eL} - w_{eL} - z(q_{min}))exp^{-r}dt < \int_0^{\infty} [E_L e_{eL} - w_{eL} - z(q_{eL})]exp^{-rt}dt \tag{8}$$

$$w \geq rV^{UE} + \frac{c(e)(r+b+q)}{q} \tag{9}$$

with respect to q, e and w. As a result of the first constraint, firms are able to commit toward a given monitoring level. Recall that if a firm deviates it makes a positive profit in the current period and 0 profits in future periods. The second constraint is the workers' IC constraint; it always binds since otherwise firms can increase their workers' wage and utility while still committing toward a given level of monitoring.

Rearranging Equation (6) yields:

$\frac{\int_0^1 exp^{-rt}dt}{\int_0^{\infty} exp^{-rt}dt} < \frac{E_L e - w - z(q_n)}{E_L e_{cL} - w_{cL} - z(q_{min})}$.

We denote by r^* the interest rate that solves this condition. Hence, for $r < (>) r^*$ the firm can (cannot) commit toward a given monitoring level. This proves (i) and (iii).

[8] Denote by E_H* the value of E_H such that the following equation holds, $E_H - c'(e_L)(1 + \frac{(r+b)}{q}) = 0$. Then, we can show that if $E_H = E_H*$ both types of firms require the same amount of effort while if $E_H > E_H*$ high-tech firms require a higher amount of effort then low-tech firms. Also note that if $E_H < E_H*$ the IC constraint does not bind for high-tech firms, and in that case the difference between high-tech and low-tech firms is small and both types of firms require the efficient amount of effort.

We prove (ii) using the arguments which were used on the first proposition.■

Proof of Proposition 3

High-tech firms maximize their instantaneous profits:

$E_H e_{eH} - w_{eH} - z(q_{eH})$

$s.t \int_0^1 (E_H e_{eH} - w_{eH} - z(q_{min}))exp^{-rt}dt + \int_1^\infty (E_H e_{cH} - w_{cH} - z(q_{min}))exp^{-rt}dt < \int_0^\infty (Ee_{eH} - w_{eH} - z(q_{eH}))exp^{-rt}dt$

$w \geq rV^{UE} + \frac{c(e)(r+b+q)}{q}$

and the second constraint binds (otherwise the firm can increase its profits). Note that q and e are given by the FOC of Equation (4).

We prove the first part of the above proposition using Equation (7).

We prove the second and third parts of the proposition using the same arguments as the ones used on the proof of the second and third parts of Proposition 2. However, the second expression of the first constraint equals π_{cH}, which is given in Proposition 1.■

APPENDIX B

We turn to the calculation of V^U. In Shapiro and Stiglitz (1984), $V^U = \frac{\bar{w}+\alpha(V^{NE}-V^U)}{r}$ where $\bar{w}$ denotes unemployment benefits and α the job acquisition rate. They assume that $a = \frac{bL}{N-L}$, where N denotes the size of the labor force and L the number of employed workers which equals the number of firms. We use a similar setup but make a modification to allow for two types of firms. Since the number of workers employed by each type of firms is constant we obtain that in our settings $\alpha(\beta)$ is the job acquisition rate at low- (high-) tech firms where $\alpha = \frac{bL^L}{N-(L^H+L^H)}$ while $\beta = \frac{bL^H}{N-(L^H+L^H)}$ and we obtain that

$$V^U = \frac{\bar{w} + \alpha(V^{NL} - V^U) + \beta(V^{NH} - V^U)}{r} \tag{10}$$

where V^{NL} (V^{NH}) denotes the expected lifetime utility of an employed non-shirker in a low- (high-) tech firm.