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IZA DP No. 17000

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MAY 2024

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ISSN: 2365-9793

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ABSTRACT

Monitoring and Prudence

We study the impact of monitoring in a workplace context where both firms and employees are unable to perfectly observe the individual worker contribution to total output. Therefore, in our setting monitoring is not aimed at reducing information asymmetries but still affects effort and output. We show that if individuals are prudent, firms call for less monitoring. Workers' stance towards monitoring is ambiguous and depends on risk aversion and the disutility of effort. Our "prudence effect" offers some clues for a more nuanced interpretation of the attitudes towards monitoring by firms and workers.

JEL Classification: D81, J24, M52
Keywords: monitoring, prudence, workers' effort

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1 Introduction

The literature on monitoring in workplaces has essentially focused on benefits and costs for an employer to keep track of one of the inputs in the production function, that is the (not perfectly observable) employee's effort. In this asymmetric information context, inquiries into the effects of monitoring on employee' effort have elicited two distinct responses.

In a standard principal-agent setting, firms get clues on the effort workers provide by monitoring their activity. Together with incentives embedded in labor contracts, monitoring provides a tool for achieving higher effort and a more efficient allocation of resources[1]. In these models firms push for more monitoring on the basis of efficiency arguments and workers resist it on the basis of privacy concerns and because of the disutility of effort. The equilibrium level of monitoring reflects the bargaining power of firms and workers. By reducing monitoring costs and by enabling a much more fine grained control over individual workers, digital transformation should – all other conditions being equal – imply that firms exert a stronger push for monitoring. In the extreme case in which firms fully prevail and monitoring costs are zero, an "Orwellian" full monitoring equilibrium occurs.

An alternative line of reasoning is provided by the "crowding out" literature (Frey (1993)). Borrowing from social psychology research on the subject, the proponents of this hypothesis claim that monitoring, by diminishing the agents' self-esteem or autonomy, might actually dampen the inherent drive for a task. Monitoring is also a signal of mistrust that may reduce employees' incentive to exert effort. Frey contends that this crowding out effect is stronger in contexts where the principal agent personal relationship is more intense[2] .

[1] Monitoring constitutes the comparative advantage of the firm, relative to cross market bi-lateral negotiations among inputs (Alchian and Demsetz (1972)). Organizations can be seen as a network of coalitions and contracts that interplay in a three-tier principal/supervisor/agent model (Tirole (1986)). Firm size and the separation of ownership and control depend crucially on the nature and the cost of the supervision process (Calvo and Wellisz (1978), Fama and Jensen (1983)). Instead of monitoring, other tools can be adopted to solve the principal agent problem, such as a mandatory age of retirement (Lazear (1979), pay (Milgrom (1988) or unemployment (Shapiro and Stiglitz (1984)) as a motivator. A survey of the issues connected with asymmetric information within the firm can be found in Lazear (1991) and Prendergast (1999). The principal agent model has been applied in settings different from the employer-employee relationship, such as crime and law enforcement (Becker and Stigler (1974)). We refer to Laffont and Martimort (2002) for a detailed presentation.

[2] The crowding out hypothesis and the standard neoclassical agency theory are not necessarily in contradiction. In complex employer-workers relationships the effects predicted by both theories may

Despite the opposite results the standard principal agent models and the "crowding out" literature obtain in terms of the relationship between monitoring and workers' effort, both approaches share a similar setting: they consider the same source of uncertainty, that is employers' inability to (perfectly) observe workers' effort. But along the production process there may be other, important, sources of uncertainty that equally affect both workers and firms. In particular, in many situations it is almost impossible both for the employer and for the worker to determine the exact individual contribution of the latter to the firm's total output, that, on the contrary, can be more easily measured. We can think, for instance, about the individual output of a programmer working in a team that co-operates with other teams in writing a complex software. As a result of such uncertainty, the worker faces the risk of receiving a compensation that does not fully reflect her talent and effort. What is the impact of monitoring in presence of this type of risk?

We address this question by constructing a model where the difference between the actual individual output and the individual wage is a zero mean noise while firm's total output is deterministic and perfectly observable by firms and workers. So imperfect monitoring implies a redistribution among workers: some employees get less, others get more than they deserve, but the average error is zero. In our approach monitoring consists in a technology for assessing individual contribution to aggregate output. In our setting the aim of monitoring is different with respect to the standard principal-agent literature. In these models workers may deliberately shirk in order to obtain a greater utility at the expense of capital; on the contrary, in our model the deviation from the expected outcomes is stochastic and determines a redistribution of income that does not affect the wage share.

Profit maximizing firms just care about total output and costs and do not care about the fairness of the labor income distribution. Thus, we are used to think that, for given total labour costs, employers are indifferent between monitoring or not, while workers prefer it for a fairness principle. However, we borrow the concept of "prudence" developed in the financial economics literature (Kimball (1990)) and show that firms can oppose mon-

coexist, as shown in controlled laboratory experiments (Dickinson and Villeval (2008)).

itoring on the ground of profit maximization. Indeed, in this financial literature, prudent individuals save more when a zero mean risk is added to their future income. Similarly, in our setting workers increase their effort when they face higher uncertainty about their income, due to imperfect monitoring on the individual contribution to aggregate output. Therefore, an economy with lower monitoring leads to higher individual effort, thus increasing aggregate output. To the extent that noise determines a greater commitment by prudent workers, profits are higher via an increase in output. Our setting also offers some clues on the relative importance of the "prudence effect" across skill levels.

The paper is structured as follows. Section 2 presents the model and the main results. Section 3 concludes.

2 The Model

We consider the optimization problem of a worker employed in a firm with a large number of employees. These employees differ in terms of their innate level of talent $s \in [\underline{s}, \bar{s}]$, that is fixed. Their preferences are expressed in terms of a utility function $u(.)$, assumed to be increasing and concave.

The complexity of the task performed by any single employee is such that neither the worker nor the employer are able to perfectly measure her individual contribution to total output. We capture this by denoting with $\tilde{y} = f(s, e) + \tilde{\epsilon}$ the amount of output that the employer attributes to a worker with talent s. This quantity is composed by a deterministic component, $f(s, e)$, that depends on talent s and the level of effort e optimally chosen by the worker. Function $f(.,.)$ exhibits constant returns to scale, and it is increasing and concave in both arguments. Quantity $\tilde{y}$ also depends on a stochastic element, $\tilde{\epsilon}$, an error term due to imperfect monitoring. We assume that $\mathbb{E}(\tilde{\epsilon}) = 0$. So, for the law of large numbers, total output at firm level is deterministic. We also impose that the wage is a constant fraction β of $\tilde{y}$ and is totally consumed by all workers: $\tilde{c} = \beta\,\tilde{y}$. For simplicity, we ignore capital input, so firm's profits are equal to $(1 - \beta) \cdot y$.

For any given level of s, any employee must choose the optimal level of effort e that solves the following optimization problem:

$$\begin{aligned} &\max_{e} \ \mathbb{E}\left[u(\tilde{c}_s)\right] \ - \ d(e) \\ &\text{s.t.} \quad \tilde{c}_s \ = \ \beta\left[f(s,\, e) \ + \tilde{\epsilon}\right] \end{aligned} \tag{1}$$

Function $d(e)$ stands for the disutility of effort, with $d'(.) > 0$ and $d''(.) > 0$. For any given $s \in [\underline{s},\, \bar{s}]$ the F.O.C. of the above problem is

$$\beta\mathbb{E}\left[u'(\tilde{c}_s)\right] \ f'(s, e^{\star}) \ = \ d'(e^{\star}) \tag{2}$$

in which $f'(.)$ is the first derivative of the production function with respect to e. For the concavity of the production and utility functions and the convexity of $d(.)$, the second order condition is respected and $e^{\star}$ is the solution of problem (1).

Our objective is to show under which conditions the optimal level of effort chosen in the imperfect monitoring scenario, $e^{\star}$, is greater than the optimal level in case of perfect monitoring, in which $\tilde{\epsilon} = 0$. So, we consider the following problem:

$$\hat{V}(e) \ \equiv \ \max_{e} \ u(c_s) \ - \ d(e) \tag{3}$$

The F.O.C is equal to:

$$\hat{V}'(e) \ = \ \beta u'(c_s)\, f'(s, \hat{e}) \ - \ d'(\hat{e}) \ = \ 0. \tag{4}$$

Again, for the concavity of the production and utility functions and the convexity of $d(.)$ we easily get that $\hat{V}''(e) \ < \ 0$, so $\hat{e}$ is the solution of problem (3). The comparison between $\hat{e}$ and $e^{\star}$ is presented in the following Proposition,

Proposition 1 *If workers are prudent, $\hat{e} \ < \ e^{\star}$ for any value of $s \in [\underline{s},\, \bar{s}]$. This implies that the firm's total output is greater in the stochastic setting.*

The proof goes as follows. Function $\hat{V}(e)$ in (3) is concave. So $e^{\star} \ > \ \hat{e}$ if and only if $\hat{V}'(e^{\star}) \ < \ 0$ (see figure 1). We have:

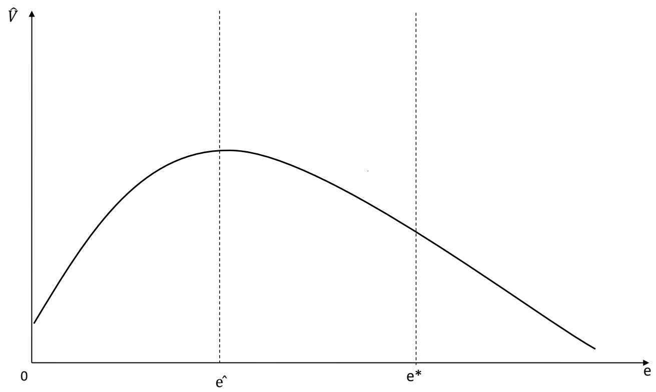

Figure 1: $e^{\star} > \hat{e}$ if and only if $u'''(.) > 0$

$$\hat{V}'(e^{\star}) = \beta u'(c_s)\, f'(s, e^{\star}) - d'(e^{\star}) = \beta u'(c_s)\, f'(s, e^{\star}) - \beta \mathbb{E}\left[u'(\tilde{c_s})\right]\, f'(s, e^{\star}). \quad (5)$$

The second equality comes from using equation (2). It is clear therefore that this expression is negative and $e^{\star} > \hat{e}$ if and only if $\mathbb{E}\left[u'(\tilde{c_s})\right] > u'(c_s)$. For the Jensen inequality, this is equivalent to say that $u'(.)$ is a convex function, that is $u'''(.) > 0$. It is therefore clear that, for any level of skill s, each individual exerts a higher effort in a imperfect monitoring case if her marginal utility is convex: $\mathbb{E}\left[\tilde{c_s}\right] > c_s$. At the aggregate level, for the law of large number, this implies that the firm's total output is larger under imperfect monitoring.

In financial economics, a positive third derivative (and a negative second derivative) of the utility function implies a positive coefficient of absolute prudence: $P \equiv \frac{-u'''(.)}{u''(.)}$. The concept of prudence has been first introduced in economics by Kimball (1990) to explain the precautionary motive for savings (i.e. to save more in presence of a riskier future income). The rationale for our results is similar: for prudent individuals the presence of uncertainty has the same effect on marginal utility of an income loss. This means that an additional unit of the consumption good has a higher value in the case of imperfect monitoring. Individuals decide to put more effort at the equilibrium. In general, it is commonly believed that individuals are prudent (Gollier (2001) and Eeckhoudt et al. (2005)):

people save more for precautionary reasons. Moreover, a positive level of prudence P is a necessary condition to have a level of risk aversion decreasing with wealth.

Following this literature (see for instance Gollier (2001, chapter 16) and Eeckhoudt et al. (2005, chapter 6)), we can denote with φ the precautionary equivalent premium, which is the sure loss in income that, for prudent individuals, is equivalent to facing uncertainty on the amount of output effectively consumed. This means that

$$\mathbb{E}\left\{u'\left[\beta\left(f(s,e^{\star})+\tilde{\epsilon}\right)\right]\right\} = u'\left[\beta f(s,e^{\star})-\varphi\right]. \tag{6}$$

The higher the value for φ is, the more prudent you are, the larger the gap between the amount of effort exerted under imperfect monitoring, $e^{\star}$, and the one exerted if there is perfect monitoring, $\hat{e}$. In presence of small risk, a second order Taylor expansion of equation (6) allows to get[3] $\varphi = \frac{1}{2}\,\mathbb{E}\,\tilde{\epsilon}^2\,P$. It is often assumed that the index of absolute risk prudence is decreasing with wealth[4]. In our setting this implies that the additional effort applied in the imperfect monitoring scenario is larger for low-skilled workers.

What are the effects of imperfect monitoring on workers' welfare? We consider the following comparison

$$\mathbb{E}\left\{u\left[\beta\left(f(s,e^{\star})+\tilde{\epsilon}\right)\right]\right\} - d(e^{\star}) \lesseqgtr u\left[\beta f(s,\hat{e})\right] - d(\hat{e}) \tag{7}$$

For any value of s, imperfect monitoring leads to higher output $f(s,e^{\star}) > f(s,\hat{e})$. This raises the term at the LHS. But two effects go in the opposite direction: the presence of risk $\tilde{\epsilon}$, that reduces expected utility for risk averse individuals, and the disutility $d(e^{\star}) > d(\hat{e})$. Notice that the term at LHS of (9) can be written as:

$$\mathbb{E}\left\{u\left[\beta\left(f(s,e^{\star})+\tilde{\epsilon}\right)\right]\right\} - d(e^{\star}) = u\left[\beta f(s,e^{\star}) - \pi\right] - d(e^{\star}), \tag{8}$$

[3]It is the same procedure used in the seminal Pratt (1964) work to measure absolute risk aversion applied to marginal utility $u'(.)$ instead of $u(.)$.

[4]This is the case for a constant relative risk aversion (CRRA) utility function: $u(f(s,e)) = \frac{1}{1-\gamma}f(s,e)^{1-\gamma}$. It is easy to check that $P = \frac{1+\gamma}{f(s,e^{\star})}$. It can be shown that $\frac{d\,f(s,e^{\star})}{d\,s} = \frac{\partial\,f(s,e^{\star})}{\partial\,s} + \frac{\partial\,f(s,e^{\star})}{\partial\,e^{\star}}\cdot\frac{\partial\,e^{\star}}{\partial\,s} > 0$.

with π denoting the risk premium. Again, a second order Taylor expansion of (8) allows us to get that $\pi = \frac{1}{2}\mathbb{E}\,\tilde{\epsilon}^2 A$. This last term is the well-known index of absolute risk aversion $A \equiv \frac{-u''(.)}{u'(.)}$.

The results are summarized in the following Proposition.

Proposition 2 *If the index of absolute risk aversion A is not lower than the index of absolute risk prudence P, then the utility of individuals is lower under imperfect monitoring, for any talent $s \in [\underline{s}, \bar{s}]$.*

To prove this, we can use equations (2) and (6) to get a comparison with the F.O.C (4):

$$u'(\beta f(s, e^\star) - \varphi) = \frac{d'(e^\star)}{f'(s, e^\star)} > \frac{d'(\hat{e})}{f'(s, \hat{e})} = u'(\beta f(s, \hat{e})) \tag{9}$$

The inequality simply comes from the fact that $e^\star > \hat{e}$ and that the ratio $d'(.)/f'(.)$ is increasing in e. In turn, a decreasing marginal utility implies that $f(s, e^\star) - \varphi < f(s, \hat{e})$. From the definitions of π and φ one easily gets that $\pi \geq \varphi \iff A \geq P$. So, if $A \geq P$, one can write: $f(s, e^\star) - \pi \leq f(s, e^\star) - \varphi < f(s, \hat{e})$. In turn, using equation (8) and the fact that $d(e^\star) > d(\hat{e})$, one obtains that the term at the LHS in (9) is lower than the term at the RHS.

It is worthwhile to notice that the financial economics literature often considers utility functions in which the opposite inequality, $P > A$, holds. This is because $P > A$ is the necessary and sufficient condition for having an index of absolute risk aversion A decreasing with wealth (see Gollier, 2001, chapter 2), a feature that is widely believed to be true. So the condition imposed in Proposition 2 is respected for just a subset of commonly used utility functions[5].

3 Conclusions

We offer a model in which prudent workers increase their effort when their compensation is noisy and therefore profit maximizing firms never aim at an "Orwellian" full monitoring.

[5]Constant absolute risk aversion utility functions respect the condition in Proposition 1, whereas CRRA functions do not.

Conversely, the call for more monitoring may arise from risk averse workers if the welfare losses associated to uncertainty and a larger disutility of effort are stronger than the output gains secured in a imperfectly monitoring setting. In general, because of this "prudence effect", less monitoring leads to more effort (as claimed in the crowding out literature) but it may have possible negative effects on welfare (in contrast to it). Our setting is also different from the "crowding out" research in that it does not rely on asymmetric information to generate firms' call for less monitoring.

Far from pretending that our alternative "prudence effect" is dominant, we argue that it allows for a more nuanced understanding of the impact of monitoring. Moreover the extent of our "prudence effect" depends on the skills of individuals and on the technology adopted. In particular, we obtain that, under fairly reasonable assumptions, the "prudence effect" is bigger for low talented workers. This may offer some clues on the different attitude towards remote working and calls for monitoring across firms and industries.

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