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Abstract: By relaxing the common efficiency wage assumption of exogenous shirking detection probabilities, we demonstrate how standards and efficiency wages are related. In a more general setting where the probability of detection depends upon the equilibrium effort level of non-shirkers, we show that the uniformly positive (negative) supply-side relationship between wages (unemployment insurance) and effort is no longer guaranteed. Profit maximization on the part of the firm, however, ensures that effort will depend positively (negatively) on wages (unemployment insurance) in equilibrium.

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1. Introduction

The fundamental premise of this paper is that efficiency wages and retention standards are related. Whilst the majority of efficiency wage literature has concentrated on imperfect monitoring of effort, we leave monitoring technologies aside and focus instead on the underlying output required by the firm; that is, the minimum *standard* a worker must deliver to continue his employment relationship with the firm. If wages determine effort and effort determines output, and if a firing standard is the critical level of output below which a worker will be fired, then it follows that wages and standards will be related. So, in a world where firms are able to observe worker output but not underlying worker effort, and where output in turn is a function of both luck (i.e. noise) and effort, there must exist a critical level of output below which the worker cannot possibly be exerting the required effort. We take this critical level to be the dividing line between a worker's retention and dismissal. If the worker's output falls short of this standard then he is fired; if it equals or exceeds the standard then he is retained and paid the going wage at the firm. We will show that the higher the wage, the higher the equilibrium level of effort and the higher the standard required of workers.

The central tenet of efficiency wage theory is that wages and effort are positively correlated. In what follows we present a stochastic shirking model in which the robustness of this relationship is tested. If standards, effort and detection probabilities are interdependent then a sufficiently low standard will ensure that all workers are retained, albeit at low wages and effort. The higher the standard, the higher the implied effort and the higher the risk of being detected as a shirker. By relaxing the literature's common assumption of exogenous shirking detection probabilities that do not depend on supply side effort and considering instead the more general and endogenous case in which shirking detection depends upon worker effort, we show that the positive supply-side relationship between efficiency wages

and effort is no longer guaranteed.¹ Such a failure may arise when both the cost of effort and the probability of detection are positively correlated with effort but where the former (latter) is positively (negatively) correlated to the wage. This result echoes findings in the monitoring literature and is potentially troubling for efficiency wage theory. However, we demonstrate that in our case this is purely a supply side issue. For when we consider the demand-side we find the efficiency wage being set in a region where the elasticity of the detection probability with respect to effort is less than unity, implying that in equilibrium effort does indeed depend positively on the wage.

Conventional efficiency wage theory has traditionally modelled worker effort as the outcome of binary choice decision; workers either shirk by supplying zero effort or they work by exerting the required level of effort. We take a broader view and model effort as a continuum that can be exerted whether working or shirking. Shirking in our context is interpreted as a neglect of duty by underperforming relative to a required effort level. It encompasses both the conventional zero effort view as well as more general cases of underexertion in relation to the firm's effort norm.² Our model is therefore closely related to those of Allgulin and Ellingsen (2002), Walsh (1999) and Strobl and Walsh (2007), who also assume continuous effort.³ By so doing, these authors demonstrate that the trade-off between monitoring and wages found in the binary effort dual labour market models of Bulow and Summers (1986) does not automatically transfer to the case where effort is continuous.⁴ We differ from these authors, however, by concentrating on standards rather than monitoring.

¹ Our paper is therefore novel in that it is the first to concentrate on endogenising detection probabilities through supply side effort effects. This sets it apart from papers that follow the tradition where demand side monitoring endogenises the risk of layoffs. Papers in the latter tradition, that study the demand side effect and the link between supervision, wages and effort, include amongst others Bujdakova (2008), Goerke (2001) Groshen and Krueger (1990) and Kruse (1992).

² Our focus is on standards rather than the psychological norms discussed in relation to unemployment and the labour market by Akerlof (1980) and Clark (2003).

³ Other authors who have considered variable effort levels include Goerke (2000), Pisauro (1991) and Strand (2003).

⁴ Hahm and Mayer (2011) show in a model of efficiency wages and search that even when effort is binary it is possible that monitoring (or detection rates) and wages are not necessarily substitutes.

This approach opens up a new series of results linking standards to effort levels and the probability of detection. Thus, we will demonstrate that shirking declines when standards are raised. Intuitively, higher standards increase the probability of detection for a given level of effort. As a result, shirkers, who optimise in their trade-off between the cost of effort and the risk of being identified, increase their effort in response to the increase in detection probability.

A question worth asking is under what circumstances will a minimum standards requirement level be the appropriate mechanism to trigger dismissal. Is it not possible that firms could use relative performance to dismiss employees? This would certainly appear to be the usual practice in team sports where athletes who underperform relative to their teammates face termination of their contracts. It follows from this that an alternative modelling strategy, in which relative performance plays a more prominent role, might be to adapt a tournament model in the Lazear and Rosen (1981) tradition to incentivise workers through punishment rather than reward; i.e. where relatively poor performing workers are sacked. From an economic perspective it makes sense for the firm to evoke such a firing trigger strategy if performance is noisy but all employers face the same aggregate unobserved shock. On the other hand, if shocks are idiosyncratic rather than common, as in our model, then tournaments are dominated by contracts as initially demonstrated by Green and Stokey (1982). Our paper therefore does not follow the tournament route but is more akin to the literature on standards or thresholds as part of incentive schemes. Although these have been typically ignored in the efficiency wage literature, they have a long tradition elsewhere. For instance, an early exposition by Mirrlees (1974) investigates how it might be optimal to punish agents who do not reach a given performance threshold. There is also a growing literature relating to bonuses, emanating from Healy (1985), in which CEO's seek to shift

earnings (output performance) to later periods whenever performance exceeds an upper threshold.⁵

It is apparent from the above discussion that whether relative or absolute performance is the chosen measurement criteria for dismissal depends on the nature of shocks and the underlying economic reasoning. However, it is not the whole story since legal frameworks and employment law may also play important roles. There are varying limitations across different judicial regions on when you can fire workers - see, for instance, Blau and Kahn (1999) for a discussion of employment-protection legislation that makes it costly or difficult for employers to terminate jobs without cause. If such legislation is enforced and absolute standards of performance are used in court or in industrial tribunals, then these legal restrictions may suggest that absolute standards in firing may be more appropriate than relative performance criteria to determine dismissals. Thus, absolute performance measures may be particularly applicable to legal jurisdictions with extensive employment protection, such as the original member countries of the European Union. The legal argument for absolute performance may apply to a lesser extent in the United States where the general rule is that firms have the right to fire at will, although even here unjust firing laws exists.

We proceed in Section 2 to develop a model which maintains an absolute standard of acceptable worker related output, below which workers are fired, to investigate the interdependent effects of standards, effort, wages and the probability of shirker detection. In Section 3 we conclude.

⁵ For an exposition on how bonuses relate to two thresholds - a lower one where bonuses kick in and a higher one where bonuses are capped - see Murphy (1999, 2013) and Murphy and Jensen (2011).

2. The Model

We present an efficiency wage model in the Shapiro and Stiglitz (1984) tradition that is extended to include a stochastic element. We consider the case where the firm observes worker output but where output is a function of both worker effort and an idiosyncratic stochastic shock. Workers are retained and paid the efficiency wage providing their observed output does not fall below a defined standard.

Workers are identical, risk neutral and endowed with a separable utility function, $u(w, e) = w - c(e)$, where w and $e \in [0, e^+]$ denote income and worker effort respectively and where $c(\cdot)$ is a continuous and convex cost function with $dc(e)/de \equiv c'(e) > 0$, $d^2c(e)/de^2 \equiv c''(e) > 0$ and $c(0) = c'(0) = 0$.⁶ Each worker is associated with a stochastic output function, $y_i = \theta_i f(e)$, which varies with state i . Workers choose effort prior to the realisation of this output shock and technology is such that $df(e)/de \equiv f'(e) > 0$, $d^2f(e)/de^2 \equiv f''(e) < 0$, $f(0) = 0$ and $f'(0) = \infty$. The shift-parameter, θ_i , represents a random shock to productivity in state i and is uniformly distributed between θ_L and $\theta_H > \theta_L$. For an individual worker θ_i reflects relative misfortune (when it is low) or luck (when it is high).

The firm's objective is to maximise the per-worker expected profit function, $\pi = \theta_i f(e) - w$ subject to providing the worker with at least his outside option (e.g. unemployment insurance) utility $b < w$.⁷ Writing this participation constraint as:

⁶ Note that the function $c(e) = Ae^\alpha$, where $\alpha > 1$, which naturally embeds the quadratic cost function, satisfies these conditions.

⁷ Note that we have normalised the product price to equal unity for the sake of simplicity.

$$\begin{aligned}
u(w^r, e) &= w^r - c(e) = b \\
\Rightarrow \\
w^r &= w^r(b, e) = c(e) + b
\end{aligned} \tag{1}$$

yields an inverse function in which the reservation wage, w^r , depends on effort and the outside option. The nature of this relationship is ascertained from totally differentiating expression (1) vis: $dw^r/de \equiv w'_e(b, e) = c'(e) > 0$; $d^2w^r/de^2 \equiv w''_{ee}(b, e) = c''(e) > 0$; $dw^r/db \equiv w'_b(b, e) = 1 > 0$ and $d^2w^r/db^2 \equiv w''_{bb}(b, e) = 0$. Thus, the firm's profit maximising level of effort, e^* , is defined implicitly from:

$$\frac{\partial \pi(b, e)}{\partial e} = \pi_e(b, e^*) = \theta_i f'(e^*) - w_e(b, e^*) = 0 \tag{2}$$

The problem facing the firm is that whilst it is able to observe worker output, it is unable to observe either worker effort, e , or 'luck', θ_i . Nonetheless, it seems reasonable to assume that in some instances effort can be partially deduced. To reflect this, consider the case where the firm sets a 'standard'; that is, a minimum level of output, \tilde{y} , that the worker must attain in order to be retained in the workplace. We define a critical realisation of the random shock, $\tilde{\theta}$, below which shirking (i.e. supplying less than required effort) will always be detected. Formally, we assume:

$$\tilde{y} = \theta_L f(e^*) = \tilde{\theta} f(e) \tag{3}$$

where e^* denotes the firm's choice level of effort and $e < e^*$ denotes any 'shirking' level of effort. Thus, the worst case scenario when the worker supplies the firm's desired level of effort in the least favourable state of nature defines implicitly a critical state of nature at which anything less than required effort will be detected. The critical state therefore satisfies:

$$\tilde{\theta} \equiv \tilde{\theta}(e, e^*) = \frac{\theta_L f(e^*)}{f(e)} \quad (4)$$

It is apparent that the critical state is increasing in the firm's desired level of effort and decreasing in shirking effort:

$$\frac{\partial \tilde{\theta}}{\partial e^*} \equiv \tilde{\theta}_{e^*}(e, e^*) = \frac{\theta_L f'(e^*)}{f(e)} > 0 \quad (5)$$

$$\frac{\partial \tilde{\theta}}{\partial e} \equiv \tilde{\theta}_e(e, e^*) = -\frac{\theta_L f(e^*) f'(e)}{[f(e)]^2} < 0 \quad (6)$$

Intuitively, a higher desired level of effort on the part of the firm raises the acceptable bar of output performance (i.e. the standard \tilde{y}) resulting in more states in which shirking is identifiable. Thus, the temptation to shirk declines with the equilibrium level of non-shirking effort as potential shirkers can expect to be detected more frequently and must hence hope for a higher realisation of luck to avoid being dismissed.

These assumptions are represented in Figures 1 and Figure 2 following. Recalling that both a shirker and a non-shirker choose their effort level prior to the realisation of the state of the world, the figures reflect possible output levels. The two upward sloping lines in Figure 1 depict the outputs generated by a shirking worker, $y_i = \theta_i f(e)$, and a non-shirking worker, $y_i = \theta_i f(e^*)$. Since the firm is only able to observe output, but not its constituent elements (i.e. effort and luck), it is unable to distinguish between a shirker whose productivity realisation is $\tilde{\theta}(e, e^*)$ and a non-shirker whose productivity realisation is at the lower bound θ_L . More generally, the firm is unable to detect shirking at any productivity realisation $\theta_i \geq \tilde{\theta}(e, e^*)$. Shirking is, however, detectable at any productivity realisation $\theta_i < \tilde{\theta}(e, e^*)$

since the revenue from shirking here falls short of the lowest output possible for a non-shirker. In terms of Figure 2, an increase in the equilibrium non-shirking level of effort from e_0^* to $e_1^* > e_0^*$, which is equivalent to an increase in the standard from \tilde{y}_0 to $\tilde{y}_1 > \tilde{y}_0$, increases the critical shift parameter from $\tilde{\theta}(e, e_0^*)$ to $\tilde{\theta}(e, e_1^*) > \tilde{\theta}(e, e_0^*)$. Thus, as the lowest possible output for non-shirkers increases, potential shirkers need to be even luckier to avoid detection.

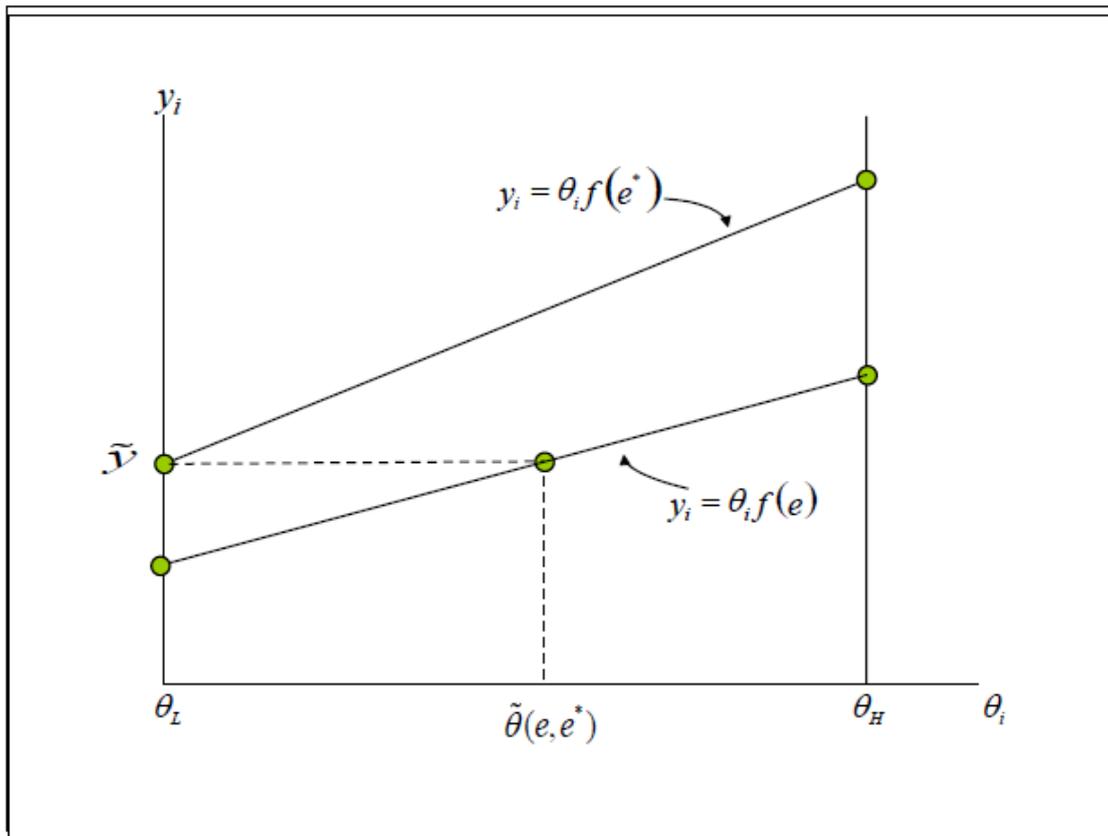


Figure 1: Critical 'Luck'

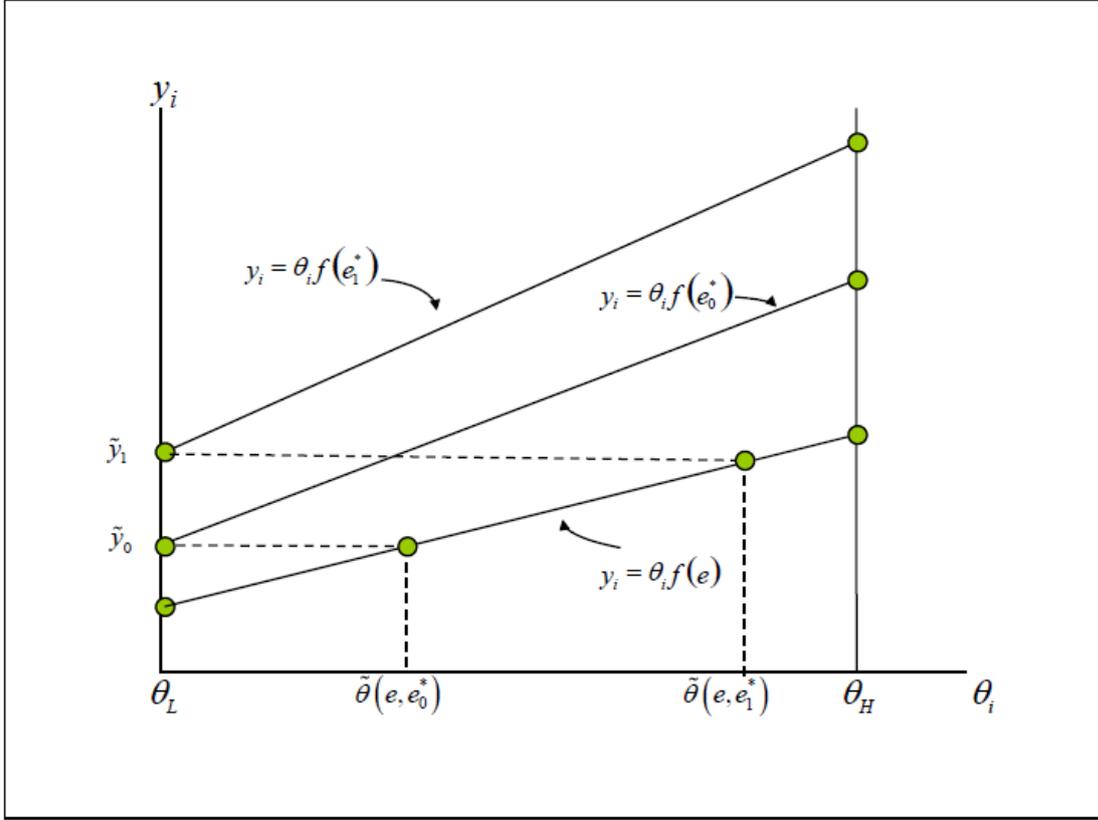


Figure 2: Critical 'Luck' and Effort

Assuming no Type-2 errors on the part of the firm such that only shirking workers are fired, then the probability of a shirker being detected and fired is given by:

$$p \equiv p[\tilde{\theta}(e, e^*)] = \frac{\tilde{\theta}(e, e^*) - \theta_L}{\theta_H - \theta_L} = \frac{\theta_L}{\theta_H - \theta_L} \left[\frac{f(e^*)}{f(e)} - 1 \right] \quad (7)$$

In contrast to the conventional efficiency wage story, this probability is determined endogenously by the equilibrium level of effort. Indeed, we derive:

Proposition 1: The probability of detecting shirking depends positively on the equilibrium effort level of non-shirkers.

Proof: Partial differentiation of expression (7) above yields $\partial p / \partial e^* = \tilde{\theta}_{e^*}(e, e^*) / (\theta_H - \theta_L) = \theta_L f'(e^*) / f(e) (\theta_H - \theta_L) > 0$.

QED

As Proposition 1 states and Figure 2 illustrates, the probability of detecting (and thus dismissing) a shirker increases with equilibrium effort since this raises the critical shift parameter, leaving the transgressor less states in which to hide. That is, workers who raise their effort level to the gratification of firms do so to the detriment of potential shirkers who are more readily identifiable. Proposition 1 is thus in sharp contrast to previous literature in which effort and detection probabilities are unrelated.⁸ As equilibrium effort effectively determines the critical dismissal-retention output, \tilde{y} , we can also draw inferences between standards and the probability of detection. Thus, within an efficiency wage framework we find that increasing standards increases the probability of detection. This echoes the findings of Rasmusen and Zenger (1990) who, using a teamwork model of agency in the Holmstrom (1982) tradition, demonstrate that the probability of detecting shirking increases with the output target set.

The expected utility from shirking, which is detected only if $\theta < \tilde{\theta}$, is given by:

$$u(e, e^*) = pb + (1-p)w - c(e) \quad (8)$$

It can be shown that shirking workers will never provide zero effort. To be sure:

Proposition 2: *A shirking worker will operate in the region $e \in (0, e^*)$.*

Proof: *See Appendix.*

If the probability of detecting shirking is endogenous then it follows that shirkers will not necessarily exert zero effort, as is commonly assumed in the efficiency wage literature.

Whilst shirkers by definition exert less effort than that required by the firm, they trade off the

⁸ Though not directly linked, Proposition 1 suggests a fair amount of introspection with respect to effort in relation to internal effort levels within the firm, not dissimilar to the discussion in Akerlof and Yellen (1990) and Danthine and Kurmann (2009) where the central theme is the relative wage within the firm as opposed to an external reference wage.

cost of effort against the reduction in the detection probability and do best by exerting at least some effort.

Note that if the standard is set sufficiently high, or the wage sufficiently low, then all (identical) workers will shirk - in the sense that they fail to provide the level of effort consistent with always attaining the standard set by the firm. They then will all run the risk of being fired. In this case we note:

Proposition 3: *When all workers shirk an increase in the wage will increase effort such that $de/dw > 0$.*

Proof: *This can be demonstrated by totally differentiating the first-order utility maximising condition (given in the proof of Proposition 2) with respect to wages and effort.*

$$\begin{aligned} \frac{de}{dw} &= \frac{\frac{\partial p}{\partial e}}{\frac{\partial^2 p}{\partial e^2}(b-w) - c''(e)} \\ \Rightarrow & \\ \frac{de}{dw} &= \frac{f'(e)f(e)}{\left[f''(e)f(e) - 2f'(e)^2 \right](b-w) + c''(e)f(e)^3 \left[\frac{(\theta_H - \theta_L)}{\theta_L f(e^*)} \right]} > 0 \end{aligned} \tag{9}$$

since:

$$\frac{\partial p}{\partial e} = -\frac{f'(e)}{f(e)^2} \left[\frac{\theta_L f(e^*)}{(\theta_H - \theta_L)} \right] < 0 \tag{10}$$

And:

$$\frac{\partial^2 p}{\partial e^2} = -\left[\frac{f''(e)f(e) - 2f'(e)^2}{f(e)^3} \right] \left[\frac{\theta_L f(e^*)}{(\theta_H - \theta_L)} \right] > 0 \tag{11}$$

QED.

The conventional efficiency wage result that wages and effort are positively correlated is retained. Higher wages increase the fear of dismissal and induce shirkers to raise effort, albeit not necessarily to the required standard.

We are now able to draw inferences as regards how shirkers react to standards within the firm and outside opportunities.

Proposition 4: Shirkers will exert: (a) more effort the higher the standard, \tilde{y} (as reflected by a higher e^*) set by the firm; and (b) less effort the higher the outside option utility, b :

Proof: Part (a) can be demonstrated by totally differentiating the first-order utility maximising condition (given in the proof of Proposition 2) with respect to shirking effort, e , and standard (i.e. non-shirking) effort, e^* :

$$\begin{aligned} \frac{de}{de^*} &= - \left[\frac{\frac{\partial^2 p}{\partial e \partial e^*} (b-w)}{\frac{\partial^2 p}{\partial e^2} (b-w) - c''(e)} \right] \\ &\Rightarrow \\ \frac{de}{de^*} &= - \left[\frac{f'(e^*) f'(e) f(e) \theta_L (b-w)}{\Phi \theta_L f(e^*) (b-w) + c''(e) f(e)^3 (\theta_H - \theta_L)} \right] > 0 \end{aligned} \tag{12}$$

where $\Phi = f''(e) f(e) - 2f'(e)^2$. Part (b) can similarly be proven by differentiating this condition with respect to shirking effort, e , and outside option utility, b , yielding:

$$\begin{aligned} \frac{de}{db} &= - \left[\frac{\frac{\partial p}{\partial e}}{\frac{\partial^2 p}{\partial e^2} (b-w) - c''(e)} \right] \\ &\Rightarrow \\ \frac{de}{db} &= - \left\{ \frac{f'(e) f(e)}{\left[f''(e) f(e) - 2f'(e)^2 \right] (b-w) + c''(e) f(e)^3 \left[\frac{(\theta_H - \theta_L)}{\theta_L f(e^*)} \right]} \right\} < 0 \end{aligned} \tag{13}$$

QED.

Proposition 4 reflects the considerations a potential shirker makes with respect to the possibility of being detected and fired, and so forfeiting wages in exchange for

unemployment utility. Increasing the standard, \tilde{y} (i.e. raising the required non-shirking effort level e^*), as in part (a), is equivalent to the firm becoming less tolerant as regards low output. Thus, the probability of being detected is effectively increased as result of the firm's higher standards. To countervail this effect, the shirker responds by increasing effort. The penalty of being detected is simply the difference between the wage if employed and unemployment utility if fired. Any increase in the latter, as in part (b), will have an adverse effect on effort. This is a common result in the traditional shirking literature, where typically no one shirks in equilibrium. The novel aspect here is that this result translates into a situation where some or all workers shirk.

Consider now the worker's decision problem over effort vis. supplying the effort required to attain the standard and supplying a lower (i.e. shirking) level of effort. The surpluses from shirking and not shirking are respectively $pb + (1-p)w - c(e)$ and $w - c(e^*)$. Thus, the worker's decision problem is:

$$\max_e \mathbf{E}\{u(w, e)\} = p(e)b + [1 - p(e)]w - c(e) \quad (14)$$

where:

$$p \equiv p[\tilde{\theta}(e, e^*)] = \begin{cases} 0 & \forall e \geq e^* \\ \frac{\theta_L}{\theta_H - \theta_L} \left[\frac{f(e^*)}{f(e)} - 1 \right] & otherwise \end{cases} \quad (15)$$

Clearly, there will either be an interior or corner solution to this maximisation problem. If the former, then the worker's optimal choice of effort, \tilde{e} , is derived implicitly from the first order condition:

$$\frac{\partial \mathbb{E}\{u(w, e)\}}{\partial e} = \frac{f'(\tilde{e})}{f(\tilde{e})^2} \left[\frac{\theta_L f(e^*)}{(\theta_H - \theta_L)} \right] (w - b) - c'(\tilde{e}) = 0$$

$$\Rightarrow$$

$$\frac{f'(\tilde{e})}{f(\tilde{e})^2} \left[\frac{\theta_L f(e^*)}{(\theta_H - \theta_L)} \right] (w - b) = c'(\tilde{e}) \quad (16)$$

Intuitively, a potential shirker will provide effort up to the point at which the marginal benefit from so doing, namely the reduction in the probability of losing the rent of wages over unemployment insurance, equals the marginal cost of increasing effort.

Given the probability of detection, the supply of effort from non-shirking workers will be determined by an incentive compatible ‘non-shirking constraint’ (NSC). This specifies the lowest wage a worker will accept in return for supplying a given level of effort or, equivalently, the maximum effort supplied for a given wage. Intuitively, workers will provide the firm’s required level of effort, e^* , if the expected utility from so doing is at least as great as that from shirking. The NSC is thus:

$$w - c(e^*) \geq pb + (1 - p)w - c(e) \quad (17)$$

Satisfaction of the NSC implies an incentive compatible (i.e. efficiency) wage schedule:

$$w^* = b + \left[\frac{c(e^*) - c(e)}{p} \right] \quad (18)$$

The efficiency wage, w^* , is the lowest wage compatible with the provision of a given level of non-shirking effort e^* (i.e. the standard \tilde{y}). It is increasing in the worker’s outside unemployment opportunity, b , and effort cost, $c(\cdot)$, since the firm will have to pay more to induce effort when alternative employment prospects are good and when the supply of effort

is more onerous. In contrast, the wage is decreasing in the probability of detection, with workers becoming more wary of shirking as the risk of detection increases. Higher detection probabilities thus shade the necessary effort-inducing wage that the firm is obliged to offer. Since both the cost of effort and the probability of detection are positively correlated with effort but oppositely (i.e. cost of effort - positively; probability of detection – negatively) correlated with the wage, a new complexity has arisen whereby the relationship between the incentive compatible wage and effort is not unambiguously positive. To be sure:

Proposition 5: *A sufficient (but not necessary) condition for the positive supply-side correlation between the (efficiency) wage and (non-shirking) effort (i.e. $\partial e^*/\partial w^* > 0$) is that the elasticity of the probability of detection with respect to the latter, η^* , is less than unity.*

Proof: *From (18) it follows that:*

$$\frac{\partial e^*}{\partial w^*} = \frac{p}{c'(e^*) - [c(e^*) - c(e)] \frac{\partial p}{\partial e^*} \cdot \frac{1}{p}} = \frac{pe^*}{c'(e^*)e^* - \eta^* [c(e^*) - c(e)]} \quad (19)$$

where $\eta^* = (\partial p / \partial e^*)(e^*/p) > 0$ denotes the elasticity of the probability of detection with respect to effort and $p \equiv p[\tilde{\theta}(e, e^*)]$. Since $c'(e^*)e^* - c(e^*) > 0$ by the convexity of the cost function, the proposition follows.⁹

QED.

Proposition 5 illustrates a potential fissure in the positive link between efficiency wages and effort. Only by constraining the effect of effort on the probability of detection to be relatively small as compared to the effect of effort on the worker's cost (i.e. disutility of effort), are we able to retain the intuitively attractive positive correlation between the supply of effort and wages. This condition resembles those in Walsh (1999) and Strobl and Walsh (2007), both of

⁹ Proposition 5 contains a sufficiency but not a necessary requirement since effort may rise with the wage even if $\eta^* > 1$ when $c(\cdot)$ is sufficiently convex or when the difference between shirking and non-shirking effort is sufficiently small.

whom find that whether wages are positively or negatively related to the level of monitoring depends critically on the shape of the worker's effort supply curve and, in particular, whether the elasticity of the worker's disutility of effort is increasing or decreasing in effort. Proposition 5 in isolation raises concerns over the central efficiency wage tenet of a positive correlation between wages and effort.

The concern deepens when, in a similar manner, we draw conclusions regarding the level of effort exertion and changes in unemployment insurance:

Proposition 6: *A sufficient (but not necessary) condition for the negative supply-side correlation between unemployment insurance and (non-shirking) effort (i.e. $\partial e^* / \partial b < 0$.) is that the elasticity of the probability of detection with respect to the latter, η^* , is less than unity.*

Proof: *The proof follows the proof of Proposition 5 closely and is therefore omitted.*

QED.

Thus, and contrary to previous efficiency literature, we are no longer certain that higher unemployment insurance results in lower effort.

We now turn to the firm's behaviour when it sets standards at such a level that no workers shirk in equilibrium. The analysis surrounding Propositions 5 and 6 is supply driven; rather than tying down a particular wage-effort combination, it investigated an incentive compatible locus of wage and effort combinations. To identify the equilibrium level of effort and the efficient wage from this locus, we turn to the demand side where the firm maximises profits subject to workers behaving according to their previously determined supply (i.e. pay-effort) schedule. Thus, armed with the knowledge of how workers respond in terms of effort to changes in pay, the firm will set the level of compensation that maximises profit. We now derive:

Proposition 7: The firm will always choose an operational wage such that $\partial e^*/\partial w^* > 0$.

Proof From (2) and (18) it follows that:

$$\begin{aligned} \frac{\partial \pi}{\partial e^*} &= \theta_i f'(e^*) - \frac{c'(e^*) - [c(e^*) - c(e)] \frac{\partial p}{\partial e^*}}{p^2} = 0 \\ \Rightarrow & \\ \theta_i f'(e^*) &= \frac{c'(e^*) - [c(e^*) - c(e)] \frac{\partial p}{\partial e^*} \frac{1}{p}}{p} \end{aligned} \tag{20}$$

Note that since the left hand side of (18) is positive the right hand side by deduction also has to be positive. From expression (19) the proposition follows.

QED.

Proposition 7 thus stands in contrast to the discussion following Proposition 5 which suggested that workers would, under certain circumstances, want to reduce their effort in response to an increase in wages. Indeed, it offers a resolution to the problematic result, contrary to the central premise of the efficiency wage literature, that higher wages might in some situations induce lower effort. Proposition 7 states that firms will always set wages such that the positive efficiency wage correlation between wages and effort holds. There is, however, no internal conflict between the conditions that underpin Proposition 5 and Proposition 7. For whilst Proposition 5 merely reflects supply responses, both demand and supply factors play a role in Proposition 7. Note that given Proposition 7, and given the close relationship between Proposition 5 and Proposition 6, it must also be true that the firm operates in a region where an increase in unemployment insurance will induce a decline in effort.

3. Final Comments

Our model as it stands illustrates a more nuanced picture regarding wages, effort and standards than previously acknowledged. Shirkers are no longer those workers who provide zero effort. They are instead those who neglect their duties by working less than required and who act rationally in so doing by trading off the cost of effort and the probability of detection. Thus, they work harder the higher the wage and the higher the standard set by the firm. By assuming continuous effort and endogenous detection, we identify conditions under which higher wages reduce effort whereas higher unemployment insurance increases effort, both of which raise questions regarding the validity of the efficiency wage literature. We nevertheless offer a resolution to this set of two potentially disturbing results as our case is demonstrated to apply only to the supply side. For when we also take the into account demand side it becomes evident that the firm will always choose to to operate in the region where workers respond to higher wages or lower unemployment insurance by increasing effort.

Monitoring technology has been central to large swathes of the efficiency wage literature. And whilst there are good and natural reasons for this, a departure from a focus on monitoring to one where observable output is used as a signal for effort has allowed us to construct a stochastic efficiency wage model within which we can investigate the largely neglected connections between standards and efficiency wages. The model we have proposed is one in which workers face idiosyncratic shocks to their output. As such, it is natural that the firm should use absolute performance criteria when considering firing. Were we to alter this assumption and consider the case where shocks instead are common to all workers, it may be more appropriate to use relative performance measures, with a relatively poor performance by a worker being used as the trigger mechanism resulting in a dismissal. Whilst such ‘avoid the drop’ tournaments are worthy of further investigation, they have remained unexplored here and are instead left for future research.

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Appendix

Proof of Proposition 2

The strict inequality $e < e^*$ follows by definition. The strict inequality $e > 0$ follows from first rewriting the expected utility from shirking as:

$$u(e, e^*) = pb + (1-p)w - c(e) = w + \left[\frac{\frac{\theta_L f(e^*)}{f(e)} - \theta_L}{\theta_H - \theta_L} \right] (b-w) - c(e) \quad (\text{A1})$$

The optimal level of shirking effort is derived from the first- and second-order conditions:

$$\frac{\partial u(e, e^*)}{\partial e} \equiv u_e(e, e^*) = \frac{\partial p}{\partial e} (b-w) - c'(e) = - \left[\frac{f'(e)}{f(e)^2} \right] \left[\frac{\theta_L f(e^*)}{(\theta_H - \theta_L)} \right] (b-w) - c'(e) = 0 \quad (\text{A2})$$

$$\frac{\partial^2 u(e, e^*)}{\partial e^2} \equiv u_{ee}(e, e^*) = \frac{\partial^2 p}{\partial e^2} (b-w) - c''(e) = - \left[\frac{f''(e)f(e) - 2f'(e)^2}{f(e)^3} \right] \left[\frac{\theta_L f(e^*)}{(\theta_H - \theta_L)} \right] (b-w) - c''(e) < 0 \quad (\text{A3})$$

Since $\lim_{e \rightarrow 0} f(e) = 0$ and $\lim_{e \rightarrow 0} f'(e) = \infty$, then $\lim_{e \rightarrow 0} \left[f'(e)/f(e)^2 \right] = \infty$. Given that $\lim_{e \rightarrow 0} c'(e) = 0$ we have:

$$\lim_{e \rightarrow 0} u_e(e, e^*) = - \left[\frac{f'(e)}{f(e)^2} \right] \left[\frac{\theta_L f(e^*)}{(\theta_H - \theta_L)} \right] (b-w) - c'(e) > 0 \quad (\text{A4})$$

Supplying zero effort is therefore not optimal.

QED