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Power, productivity and profits

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Abstract

New information and communication technologies, we argue, have been 'power-biased': in many industries they have allowed firms to monitor workers more closely, thus reducing the power of these workers. An efficiency wage model shows that 'power-biased technical change' in this sense may generate rising inequality accompanied by an increase in both unemployment and work intensity.

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Key words: power-biased technical change, efficiency wages, inequality, work intensity.

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1 Introduction

A change in workplace technologies may affect the relative earnings of workers in at least two distinct ways. One is through the market for skill, the other through workers' power in relation to their employers. Increases in earnings inequality since the late 1970s in many industrial economies - and in particular, in liberal market economies like the US and UK - have been explained by many economists as a consequence of skill-biased technological change (SBTC). However, the evidence cited for SBTC can be read instead as evidence that new technologies affect the distribution of earnings not through supply and demand, but through changes in the relative power of different groups of employees. The reasons for these changes are detailed in Guy (2003) and the implications are analyzed more formally by Guy and Skott (2005) and Skott and Guy (2007).

This paper explores the implications of power-biased technical change for the functional distribution of income. Empirically, it is not just earnings inequality among workers that has increased. There have also been significant changes in the functional distribution of income. In the US real wages have stagnated or fallen for most workers, and the share of wages and salaries in GDP has fallen dramatically in both the US and many European countries (e.g. De Long (2005), Blanchard and Wolfers (2000)). Over the same period the remuneration of top managers has sky rocketed, and the decline in wages has been associated with relatively weak productivity growth and an intensification of the work process (Piketty and Saez (2003), Green (2004)).

Although our analytic framework is similar to theirs, our use of the "power" term is slightly different than that of Bowles and Gintis (1990). In their usage, efficiency wage models like the one used here show the employer exercising power over the employee through the payment of an employment rent, combined with the threat of dismissal (which is a threat to withdraw the rent). However - in their model, as in ours - this rent depends on the employee's ability to affect profitability by varying effort. We understand that ability of the employee as representing power, as well. Thus, an employee has power, in relation to the employer, because of the employee's ability to affect outcomes that matter for the employer.

All jobs entail some power, according to this use of the term: an investment banker makes investments which may make or lose millions for the bank, and a burger flipper can burn a few batches of burgers; the difference in degree is important, but in both cases there is an agency problem with which the employer must reckon. Among the factors which determine the employee's power are the extent of the assets or operations concerning which the employee makes decisions; the quality and timeliness of the employer's information about the employee's actions; and the quality and timeliness of the employer's information about the situation in which the employee acts (the 'state of nature'). Employers also have power over their employees. With incomplete contracting for employee actions, employers will typically want to pay a wage in excess of what their workers can expect if fired. Thus, the employer's ability to fire a worker (thereby reducing the worker's utility) is a source of power to the employer. This paper considers technological change that affects the balance of power between workers and employers.

A large Marx-inspired literature has analyzed how firms' choice of technique can be influenced by considerations of power. Important contributions include, among others, Marglin (1974) and Braverman (1974). Our paper is closely related, in particular, to Bowles (1989) and Green (1988).

Quoting Marx's (1967, p. 436) statement that "it would be possible to write quite a history of the inventions made since 1830, for the sole purpose of supplying capital with weapons against the revolts of the working class", Bowles goes on to describe how the pursuit of profit may lead capitalist firms to choose "capitalist technologies" that are technically inefficient but enable firms to reduce wages and/ or enforce an increase in the intensity of work. A similar argument is presented by Green (1988), and both papers contain some formal modeling to back up the argument. The modeling, however, is partial and it is not carried very far. Thus, the main contribution of this paper is to reconsider and refine ideas that have been around in the Marxian literature for a long time and to relate these ideas to recent changes in information and communication technology (ICT).

The paper is structured in five sections. Section 2 describes and discusses some of the ways in which employee power - and thus the willingness of firms to pay - will be affected by changes in ICT. In Section 3 we set up a formal model and derive some comparative static results. Section 4 considers the stability of the different steady states, and section 5 summarizes the main conclusions.

2 ICT and monitoring

New ICT should not be seen as something that is simply plugged into organizations, with the organizations otherwise unchanged. The use of new ICT is often tied up with choices about larger changes in the organization of work. This paper is related to a large empirical literature on the relationships between ICT, the organization of work, and power (for instance, Drago 1996; Guy 2003; Hunter and Lafkas 2003; Ramirez et al 2007; Sewell 1998).

New technologies, and in particular ICTs, allow organizations to become flexible, flat, decentralized, customer-oriented, and as a consequence to give employees increased discretion. But not every employee who uses new ICTs has been given a charter for increased decision making. ICTs facilitate increased flexibility in the coordination of activity by making it cheaper to gather information about, among other things, what employees do (monitoring), and to fine tune the instructions given to employees. The industrial sociology and human resource management literatures abound with examples of large classes of employees, often in expanding parts of the economy such as wholesale and retail trade, financial services, hotels and restaurants, whose use of up to date ICTs is associated with more detailed instruction sets and closer monitoring.

The process is complex, and it can be difficult, even *ex post,* to sort out what is the net change in discretion for any particular employee. The use of the new technologies often entails, or is associated with, significant changes in the way organizations are managed and individual jobs are structured. These changes are not easy to characterize, because they take a number of different forms, and also because the rhetoric of organizational transformation is not always a good guide to reality.

As an extreme case, assume for the moment that although ICTs improve, the task the employee is asked to complete does not change. Improved monitoring may narrow the scope of action open to a worker in two ways. One is that the manager has a better idea of what the worker actually does. The other is that the manager has better information about the environment in which the worker works, the options she faces and the effect that different actions the worker might take would have on completion of the task. In other words, the manager has improved knowledge of both the worker's actions, and the state of nature in which those actions take place. For instance, prior to the 1980s a truck driver's employer usually had only a vague idea of where he and the truck were. Now the location of the truck, and even the behavior of its engine, are often tracked by satellite. The driver's task may have changed little, but his scope for taking advantage of possible slack in his schedule is diminished, and the employer has new information with which to remove slack from the schedule over time.

Contrary to the assumption made above, tasks typically do change as part of the organizational transformations that go together with the introduction of new ICTs. In many workplaces, for instance, workers who once had narrowly defined individual jobs now do all or part of their work in teams; a worker may be expected to do a number of different jobs within the team, and some teams are assigned problem-solving or decision-making responsibilities which were not previously within the remit of employees at their level. Such teamwork may enhance the scope of action open to a worker, both because of the broadening of tasks (e.g., "problem solving") and because of what may be the greater difficulty assigning individual accountability when actions are taken by teams. Changes also occur in managerial work. The de-layering of organizations, and the competitive need for organizations to be flexible, give the remaining managers a greater range of decisions to make. On the other hand, managers get monitored, too. It is tempting, especially for those of us trained to recognize the beauty of markets as examples of spontaneous, un-regimented order, to associate delegation, de-layering and decentralization as marketization, the sunset of central control. But within organizations, decentralization is typically facilitated by improved controls; the invention of the multi-divisional corporation in the 1920s, for instance, was made possible by improved cost accounting and 'management by numbers' (Chandler, 1962).

Our formal model below disregards these complications. It assumes symmetry across workers and considers technical change that enhances the ability of managers to monitor the actions of the firm's workers. Implicitly the categories of (top) management and capitalist are merged in the model. Managers may get increased discretion, but it is assumed that they want to maximize profits and that there is no agency problem in the relation between capitalists and top managers.

3 Formal model

We use a standard efficiency wage framework to analyze the effects PBTC. The keep the analysis simple, we assume price taking behavior in the product market and constant returns scale. Labour is homogeneous and the production function is CES

$$Y = A(\beta K^{-\alpha} + (1-\beta)(eN)^{-\alpha})^{-1/\alpha} \tag{1}$$

where e and N denote effort and employment, and changes in the multiplicative constant represent Hicks-neutral technical change. Leaving aside all issues of capital accumulation, we shall take K to be constant throughout this paper.

Workers' choice of effort is determined by the cost of job loss and the sensitivity of the risk of job loss to variations in effort.[1] As a formal specification, we assume that if a firm pays the wage w, the effort of its workers may be determined by the maximization of the objective function V,

$$V = p(e)[w - v(e) - h(\bar{w}, b, u)] \tag{2}$$

where $\bar{w}, u$ and b denote the average wage, the unemployment rate and the rate of unemployment benefits. Arguably the choice of effort should be determined by an optimization problem that is explicitly intertemporal. As shown in Appendix A, however, a simple intertemporal optimization model reduces to a special case of problem (2).

The function $v(e)$ describes the disutility associated with effort, and we assume a log-linear functional form,

$$v(e) = e^{\gamma}, \gamma > 1 \tag{3}$$

This specification is quite standard, the parameter restriction $\gamma > 1$ implying that given the chosen scale of effort, the disutility of effort is strictly convex.[2] The convexity assumption ensures that the firm's unit cost does not decrease monotonically as wages increase and that, therefore, an equilibrium solution for w exists.

The function $p(e)$ captures the effect of effort on the expected remaining duration of the job; since high effort reduces the risk of being fired, we have $p' > 0$. The effect of technical change on firms' ability to monitor effort may be represented by a shift in the $p-$function. The key property of this shift is that it affects the *sensitivity* of the firing rate to variations in effort. An improvement in firms' ability to monitor the efforts of individual workers makes the expected job duration of any individual worker more sensitive to changes in the

[1] Most expositions of efficiency wage models emphasize the former effect, with the risk of job loss and its dependence on effort taken as exogenous; exceptions include Bowles (1985, 1988), Gintis and Ishikawa (1987), and several subsequent joint papers by Bowles and Gintis.

[2] Effort is ordinal and the convexity assumption is conditional on the chosen scale. This scale is determined implicitly by the specification of the production function (Katzner and Skott (2004)).

worker's own effort. This property of the $p-$function can be captured by assuming that the elasticity of p can be written

$$\frac{ep'}{p} = \lambda(e, \mu) \tag{4}$$

where the parameter μ describes monitoring ability and $\lambda_\mu > 0$. It should be noted that equation (4) says nothing about the average firing rate and, as explained in appendix A, the average firing rate may be unaffected by a change in μ. Analytically, it is convenient to assume that the elasticity λ is independent of e,

$$\frac{ep'}{p} = \lambda(e, \mu) = \mu \tag{5}$$

This specification of the elasticity can be seen as a log-linear approximation of the $p-$function around the equilibrium solution for e.[3]

Using (2)-(3) and (5), the first-order condition for the worker's maximization problem can be written

$$e = [\frac{\mu}{\mu + \gamma}(w - h)]^{1/\gamma} \tag{6}$$

The wage is set by the firm. The standard first order conditions imply that

$$\frac{e_w w}{e} = 1$$

or, using (6),

$$\frac{1}{\gamma}\frac{w}{w-h} = 1$$

The solutions for the wage can now be written

$$w = \frac{\gamma}{\gamma - 1}h \tag{7}$$

The function $h(\bar{w}, b, u)$, finally, represents the fallback position, that is, the expected utility in case of job loss; the partial derivatives satisfy $h_{\bar{w}} > 0, h_b > 0$ and $h_u < 0$ under all standard assumptions. We use the specific functional form obtained from the optimization model in Appendix A:

$$h = \frac{(r + \delta)u}{ru + \delta}b + \frac{\delta(1 - u)}{ru + \delta}(\bar{w} - v(\bar{e})) \tag{8}$$

[3] Integration of (5) implies that

$$p(e) = Ke^{\mu}$$

where K is an arbitrary constant. The intertemporal interpretation in Appendix A of workers' maximisation problem implies that $p(e)$ is bounded, unlike the above expression. Thus, the approximation will be bad for 'large' values of e. It may be good, however, for effort levels in the relevant range, and all our simulations below yield modest variations in effort.

where $\bar{e}$ is determined by setting $e = \bar{e}$ and $w = \bar{w}$ in equation (6); r and δ are the discount rate and the rate of job separations, respectively. Intuitively, the fallback position is a weighted average of the utility when unemployed (b) and in an alternative job ($\bar{w} - v(\bar{e})$). The weights depend on u since (in a steady state) the unemployment rate is equal to the proportion of time one can be expect to unemployed; if there is no discounting ($r = 0$) the weights are simply u and $1 - u$ but when $r > 0$, unemployment (the initial state in case of job loss) is weighted more heavily.

Turning to the demand for labor, the first-order condition for profit maximization implies that the wage satisfies the equation

$$\begin{aligned} w &= (1-\beta)A(\beta K^{-\alpha} + (1-\beta)(eN)^{-\alpha})^{-(1+\alpha)/\alpha} e^{-\alpha} N^{-(1+\alpha)} \\ &= (1-\beta)Ae[(1-\beta) + \beta(\frac{K}{eN})^{-\alpha}]^{-(1+\alpha)/\alpha} \end{aligned} \tag{9}$$

In equilibrium, finally, $w = \bar{w}$ and $e = \bar{e}$, and using the definitional relations between unemployment u and employment N, equations (6)-(9) yield equilibrium solutions for the endogenous variables (w, e, N, h).[4]

We now introduce a decline in the power of workers (a rise in μ). Intuitively, this rise puts upward pressure on e (equation (6)) and thus, for a given value of N, on the effective labor input eN. For a given ratio of relative inputs, eN/K, a rise in e will increase the wage w (equation (9)), but w is affected negatively if the upwards pressure on eN generates a rise in the input ratio eN/K (equation (9)). This negative effect is stronger the larger is α, that is, the lower the elasticity of substitution. Strong complementarity between the inputs also implies that any rise in e tends to affect N negatively. Thus, the elasticity of substitution plays a critical role for the effects of a change in relative power.

An example is given in Table 1.[5] The rise in μ leads to an improvement in both wages and employment if A is unchanged. Given the assumptions in Appendix A, the welfare of unemployed and employed workers can be measured by $h(= rU)$ and $j = (w - e^{\gamma})\frac{r}{r+\delta} + h\frac{\delta}{r+\delta}(= rV)$, respectively, and welfare also improves.[6] This result may seem counter-intuitive at first sight but the explanation is straightforward. Agency problems lead to outcomes that are Pareto suboptimal, and the increased ability of firms to monitor effort reduces the agency problem. Taking into account the derived effects on employment and wages, workers may therefore in some cases benefit from a decline in their workplace power. The interesting aspect of Table 1, however, is that when the rise in μ from 0.1 to 0.5 is combined with a very substantial loss of technical efficiency (a 15 percent fall in A from 10 to 8.5) profits π still increase significantly while workers suffer a large reduction

[4] With inelastic labor supplies (normalized at unity), we have

$$u = 1 - N$$

[5] The table uses $\alpha = 1$. The other parameters are $\beta = 0.5, \gamma = 5, r = 0.05, \delta = 0.2, K = 1$ and $b = 1$.

[6] The values of h are proportional to w (cf. equation (7)). A separate h column is included to facilitate a comparison between the welfare measures for employed and unemployed workers.

in wages and welfare. The negative effect on profits of lower technical efficiency is more than compensated for by the decrease in workers' power and the associated changes in effort and wages.

Table 1 assumes that the elasticity of substitution in the production function is 0.5. Complementarity may be the relevant case from an empirical perspective, but it should be noted that complementarity is critical for the conclusion. Assuming profit maximization and perfect competition in the product market, for instance, a Cobb-Douglas specification implies that profits are a constant share of output, and it follows that if technological change (a shift in A and/or μ) generates an increase in profits then aggregate wages must also go up.

Table 1: Equilibrium effects of changes in monitoring

A	μ	e	w	u	h	j	π
10	0.1	0.45	4.91	0.21	3.93	4.12	1.40
10	0.5	0.63	5.53	0.19	4.42	4.62	2.29
8.5	0.5	0.61	4.68	0.20	3.75	3.91	1.83

4 Transition

The previous section looked at the comparative statics of a change in technique. The comparison of different equilibrium positions can be misleading, however. The configurations underlying Table 1 imply not only that equilibrium profits increase following the change in technique but also that the individual firm has an incentive to adopt the new technique (see Table 3a below). It is easy, however, to find examples of techniques that may yield an increase in profits if all firms were to adopt them, even though no single firm has an incentive to adopt the techniques. Conversely, individual firms may have an incentive to introduce a new technique, even if the equilibrium profits when all firms introduce the technique are lower than they would have been, had all firms kept the old technique.

Consider the decision problem of a single firm. The firm's profits depend on the technical parameters A and μ as well as on it's choice of wage and employment,

$$\begin{aligned} \Pi &= A(\beta K^{-\alpha} + (1-\beta)(eN)^{-\alpha})^{-1/\alpha} - wN \\ &= Y(A, K, e, N) - wN \\ &= \Pi(A, K, e, w, N) \end{aligned} \tag{10}$$

where

$$\begin{aligned} e &= [\frac{\mu}{\mu+\gamma}(w-h)]^{1/\gamma} \\ &= e(w, h, \mu) \end{aligned} \tag{11}$$

For any given technique and capital stock (that is, A, μ, K) the firm chooses w and N so that the first-order conditions are satisfied:

$$\frac{\partial \Pi}{\partial w} = \Pi_e e_w - \Pi_w = 0 \tag{12}$$

$$\frac{\partial \Pi}{\partial N} = 0 \tag{13}$$

4.1 Marginal changes

Now assume that a new technique offers a (marginal) change in both A and μ. Workers' fallback position is independent of the firm's own choices so h is constant, and the effect on the firm's optimal profits is given by

$$\begin{aligned} d\Pi^{partial} &= \Pi_A dA + \Pi_e(e_w dw + e_\mu d\mu) + \Pi_w dw + \Pi_N dN \\ &= \Pi_A dA + \Pi_e e_\mu d\mu \\ &= Y_A dA + Y_e e_\mu d\mu \\ &= Y[\frac{Y_A A}{Y} d\log A + \frac{Y_e e}{Y}\frac{e_\mu \mu}{e} d\log\mu] \\ &= Y[d\log A + \eta_L \frac{1}{\mu+\gamma} d\log\mu] \end{aligned} \tag{14}$$

where the second equality comes from using the first-order conditions (12)-(13) (or, equivalently, from the envelope theorem); the third equality comes from the definition of profits in (10); η_L is the share of wages in income and $\eta_L = \frac{Y_N N}{Y} = \frac{Y_e e}{Y}$ follows from profit maximization.

Equation (14) implies that the firm has an incentive to introduce the new technique if

$$d\log\mu \geq -\frac{\mu+\gamma}{\eta_L} d\log A \tag{15}$$

The incentive depends on the wage share, and the wage share, in turn, depends on the fallback position h. A rise in h implies an increase in w/e and a decline in eN/K (eqs. (6)-(7)), and if $\alpha > 0$ the decline in eN/K generates an increase in the wage share; if $\alpha < 0$, the wage share falls. Thus, although the single firm treats h as a constant, the incentives that it faces depends on h. As long as the changes in technique are purely marginal this dependence of the incentive condition on the level of h does not matter: if the change of technique is marginal the associated change in h will also be marginal, and the *level* of η_L can be taken as given. Thus, it follows from (15) that either all firms will adopt the new technique or no firms will do it. When we consider non-marginal changes in technique in the next subsection, however, the incentives will depend on whether other firms had chosen to introduce the new technique.

Even with marginal changes in technique, the induced marginal effects on the fallback position h need to be taken into account in order to calculate the equilibrium effects of changes in technique on the change in profits,

$$\begin{aligned} d\Pi^{eq} &= \Pi_A dA + \Pi_e(e_w dw + e_\mu d\mu) + \Pi_w dw + \Pi_N dN + \Pi_e e_h dh \\ &= d\Pi^{partial} + \Pi_e e_h dh \\ &= Y[d\log A + \eta_L \frac{1}{\mu+\gamma} d\log\mu] + \Pi_e e_h dh \end{aligned} \tag{16}$$

Since $\Pi_e > 0$ and $e_h < 0$ (cf equation (11)), the sign of the last term is the opposite of that of the change in the fallback position, dh. If dh is positive, then the single firm's change of technique produces a negative externality on the profits of all other firms; if dh is negative, the externality is positive. The existence of this externality lies behind the possibility that firms' individually rational decisions may lead them to adopt a technique that reduces the equilibrium level of profits. We illustrate this possibility in the next subsection which also generalizes the setting by allowing for non-marginal changes in technique.

4.2 Non-marginal changes

With non-marginal technical changes, the fulfillment of the incentive condition (15) for a single firm may depend on the proportion of firms that have introduced the new technique. Assume that workers cannot move directly from one job to another and that equilibrium firing rates are the same in all jobs (this is consistent with differences in monitoring, cf. the argument in Appendix A) and let x denote the proportion of employed workers in firms that use the new technique. With these assumptions, the fallback position h is given by (see Appendix B)

$$h(x) = [x(w^n(x) - v(e^n(x))) + (1-x)(w^o(x) - v(e^o(x))]\frac{\delta(1-u)}{ru+\delta} + b\frac{(r+\delta)u}{ru+\delta} \tag{17}$$

Equations (6), (7) and (9) still hold; the only difference is that for each of them there will now be two separate equations, one for the old and one for the new technique:

$$e^o(x) = [\frac{\mu^o}{\mu^o+\gamma}(w^o(x) - h(x))]^{1/\gamma} \tag{18}$$

$$e^n(x) = [\frac{\mu^n}{\mu^n+\gamma}(w^n(x) - h(x))]^{1/\gamma} \tag{19}$$

$$w^o(x) = \frac{\gamma}{\gamma-1}h(x) \tag{20}$$

$$w^n(x) = \frac{\gamma}{\gamma-1}h(x) \tag{21}$$

$$w^o(x) = 0.5^{-1/\alpha}A^o e[1 + (\frac{(1-z)K}{e^o(x)N^o})^{-\alpha}]^{-(1+\alpha)/\alpha} \tag{22}$$

$$w^n(x) = 0.5^{-1/\alpha}A^n e[1 + (\frac{zK}{e^n(x)N^n})^{-\alpha}]^{-(1+\alpha)/\alpha} \tag{23}$$

where z is the proportion of firms that have adopted the new technique; the proportion of firms (z) and the proportion of the employment (x) will differ if, as will generally be case, the new technique leads to a change in the capital labour ratio. By definition, finally, we have

$$N^o = (1-x)(1-u) \quad (24)$$
$$N^n = x(1-u) \quad (25)$$

For any given value of x, equations (17)-(25) can solved for the nine variables $w^o, w^n, e^o, e^n, N^o, N^n, h, u, z$.

We get four qualitatively different possible outcomes for the equilibrium value x^*: (i) $x^* = 0$, (ii) $x^* = 1$, (iii) $0 < x^* < 1$, and (iv) multiple solutions with $x^* = 0$ or $x^* = 1$. These possibilities as well as the externalities described above in the case of marginal changes can be illustrated by the examples in Tables 2-5. All tables assume that a new technique has become available and that this technique offers better monitoring ($\Delta\mu > 0$) but a lower productivity parameter ($\Delta A < 0$). The tables differ with respect to the precise values of the changes in μ and A as well as the values of other parameters.[7]

Table 2a: Neither micro incentive nor equilibrium increase in profits
(but workers would have benefitted)
$\alpha = -0.5, \gamma = 5; A^{old} = 10, \mu^{old} = 0.1; A^{new} = 8.5, \mu^{new} = 0.5$

	π^{old}	π^{new}	u	w	h	j^{old}	j^{new}
$x = 0.001$	3.88	3.60	0.26	2.87	2.30	2.41	2.40
$x = 0.999$	3.80	3.51	0.24	3.01	2.41	2.524	2.516

Table 2b: No micro incentive but equilibrium increase in profits
(and workers' utility would have dropped)
$\alpha = 1, \gamma = 5; A^{old} = 10, \mu^{old} = 0.1; A^{new} = 7.5, \mu^{new} = 0.5$

	π^{old}	π^{new}	u	w	h	j^{old}	j^{new}
$x = 0.001$	1.40	1.10	0.208	4.91	3.92	4.12	4.11
$x = 0.999$	1.97	1.54	0.207	4.12	2.30	2.41	2.40

Tables 2a-2b show examples in which no firm has an incentive to introduce the new technique with improved monitoring, that is $x^* = 0$. In 2a the equilibrium profits would

[7] All tables use $\beta = 0.5, A^{old} = 10, \mu^{old} = 0.1, r = 0.05, \delta = 0.2, K = 1, b = 1$.

decline with the introduction of the new technique while in 2b a positive externality implies that even though there is no individual incentive to introduce the technique, the new technique would in fact have generated an increase in aggregate profits. The key difference between the two scenarios is the elasticity of substitution in production. Increased monitoring increases effort at any given wage rate and thus tends to raise the ratio of effective labor (eN) to capital and/or reduce the employment-capital ratio (N/K). The effect of these changes on wages and employment depend on the elasticity of substitution. When there is complementarity ($\alpha > 0$), an increase in the effective labor-capital ratio reduces the wage share (and thus also wages and / or employment) with detrimental effect on workers' fallback position; when the inputs are substitutes ($\alpha < 0$), the rise in the effective labor - capital ratio raises the share of wages which tends to raise the fallback position. A deterioration in workers' fallback position in turn represents a negative profit externality while an improvement in the fallback position provides a positive profit externality.

Table 3a: Both micro incentive and equilibrium increase in profits (but workers' utility declines)

$\alpha = 1, \gamma = 5; A^{old} = 10, \mu^{old} = 0.1; A^{new} = 8.5, \mu^{new} = 0.5$

	π^{old}	π^{new}	u	w	h	j^{old}	j^{new}
$x = 0.001$	1.40	1.69	0.21	4.91	3.93	4.12	4.11
$x = 0.99$	1.55	1.83	0.20	4.68	3.74	3.93	3.92

Table 3b: Micro incentive but equilibrium profits decrease (and workers' utility increase)

$\alpha = -0.5, \gamma = 5; A^{old} = 10, \mu^{old} = 0.1; A^{new} = 9, \mu^{new} = 0.5$

	π^{old}	π^{new}	u	w	h	j^{old}	j^{new}
$x = 0.001$	3.88	3.98	0.26	2.87	2.30	2.41	2.40
$x = 0.99$	3.71	3.74	0.23	3.20	2.56	2.69	2.68

In Tables 3a-3b firms introduce the new technique, and in 3a equilibrium profits go up while in 3b the negative externality leads to a fall in profits. The scenario in Table 3b illustrates a falling rate of profit. This violation of the Okishio theorem (Okishio, 1961) is possible because - unlike the Okishio theorem - our analysis includes endogenous changes in the unit wage cost via the efficiency wage mechanism (other ways of introducing wage changes in the analysis of the Marxian law of the falling rate of profit have been analyzed by, inter alia, Foley (1986) and Skott (1991)).

Table 4: Interior solution

$\alpha = -0.5, \gamma = 5; A^{old} = 10, \mu^{old} = 0.1; A^{new} = 8.9, \mu^{new} = 0.5$

	π^{old}	π^{new}	u	w	h	j^{old}	j^{new}
$x = 0.001$	3.88	3.90	0.26	2.87	2.30	2.41	2.40
$x = 0.41$	3.81	3.81	0.25	2.98	2.39	2.50	2.49
$x = 0.99$	3.72	3.69	0.23	3.16	2.53	2.65	2.64

Table 5: Multiple solutions
$\alpha = -0.1, \gamma = 1.5; A^{old} = 10, \mu^{old} = 0.1; A^{new} = 4.3, \mu^{new} = 20$

	π^{old}	π^{new}	u	w	h	j^{old}	j^{new}
$x = 0.1$	1.88	1.87	0.74	5.81	1.93	2.66	1.99
$x = 0.9$	2.07	2.11	0.49	4.04	1.35	1.85	1.39

Tables 4 and 5, finally, show the possibility of an interior solution and multiple equilibria, respectively. The interior solution in Table 4 is based on an assumption of good substitutability ($\alpha < 0$), but interior solutions can be obtained both in the case of complementarity ($\alpha > 0$) and in the case of substitutability ($\alpha < 0$). The reason for this is simple. When there is complementarity, an increase in the proportion of workers and firms using the new technique will tend to reduce workers' fallback position and when $\alpha > 0$ this reduction in h generates a decline in workers' share of income; that is, the incentive condition becomes more restrictive as x increases. When $\alpha < 0$ an increase in x may (but need not) increase h, but with $\alpha < 0$ the wage share is negatively related to h and a decline in the wage share is obtained in this case too.

Multiple solutions are harder to get. In order to get multiple solutions it is assumed in Table 5 that the new technique provides a very dramatic increase in monitoring ($\mu^{new} = 20$) and that the elasticity of worker utility with respect to effort is low ($\gamma = 1.5$). As a result, the value of a job using the old technique is much higher than that associated with a job using the new technique ($j^{old} >> j^{new}$). Even though an increase in the proportion of new jobs generates an increase in employment, the employment effect is kept relatively small by using a negative but numerically small value of α. The welfare effects of the changing composition of the jobs therefore dominates, and workers suffer a net welfare loss as the proportion of jobs using of the new technique goes up. Since good substitutability is assumed ($\alpha < 0$) the decline in h generates an increase in the wage share, and the incentive condition (15) is relaxed as x increases.

5 Conclusions

ICT has a monitoring function, but the adoption of new ICT has often facilitated organizational changes which go far beyond changes in monitoring. The telegraph, the telephone, and a host of other technologies made it feasible to coordinate elaborate planned divisions of labor involving hundreds of thousands of employees in big corporations, and tens of millions in the planned economy of the Soviet Union. The rigid bureaucratic structures for which the mid twentieth century was known were a reflection of the ICTs of the day. Microprocessors and other, more recent, developments in ICT have made possible more flexible systems. Whether with regard to sweeping organizational changes such as these, or narrower changes in particular jobs or functions, the adoption of new ICT brings changes in the organization of work as well.

In this paper we have considered the implications of changes that give (top) managers increased discretion and allow them to monitor the actions of employees more closely. Changes of this kind may increase the discretion for managers while constraining the ability of (many or most) employees to make consequential choices for the organization. Discretion and its inverse, constraint, develop hand in hand.

Our analysis shows that if the same information technologies which allow the managers to prepare more accurate plans and to correct errors more quickly also enable the manager to monitor workers more closely, then we may see a polarization of incomes with workers losing out and increases in profits and managerial incomes.

One limitation of the model is the aggregation of profits and the income of top managers. With the explosion in managerial remuneration, however, the split between these two categories has changed significantly,. and by aggregating the two we leave out agency problems in the relation between managers and owners. It is unclear how this may bias our analysis of the choice of technique, but since the choice of technique is made by managers, the alternative assumption that only narrow profits (that exclude managerial remuneration) influence the choice of technique would probably represent a more serious distortion than our hybrid assumption.

The assumption of complete symmetry across all (non-managerial) workers represents another gross simplification. In fact, power-biased technical change may have been a significant factor, not just behind the increase in the share of broad profits but also behind increased inequality among workers (Guy and Skott 2005; Skott and Guy 2006). Other obvious limitations of the model concern (i) the absence of any consideration of capital accumulation when, in fact, it is hard to conceive of technical change without investment; (ii) the focus on steady states and the assumption that workers and firms have full knowledge of the various parameters underlying workers' choice of effort; (iii) the assumption that the choice takes place over some exogenously given techniques rather than allowing for decisions over how to allocate R&D resources and where to search for new techniques.

These simplifications clearly make the analysis much more tractable and relaxing the assumptions would not, we believe, invalidate the fundamental mechanism that is the focus of this paper: the pursuit of profits by private enterprise affects the choice of technique,[8] and technically inefficient production methods may be chosen if they enable firms to squeeze workers. But the analysis also shows that micro incentives and class interests do not always go together: the profit incentive will not invariably lead firms to choose the technique that gives the highest equilibrium level of profits.

Technical change typically produces losers as well as winners, also in a Walrasian world without agency problems. In the absence of agency problems, however, there is a presumption that, in principle, the winners could compensate the losers, leaving a net gain. There is no basis for the presumption of welfare improvements in the case of power-biased technical changes. A new technique can be profitable and may be adopted even if it is less efficient than existing techniques.

One final comment may be called for. We have analyzed the PBTC hypothesis using a traditional efficiency wage model as it applies to individual wage determination. This model, arguably, provides a good approximation of wage setting in the US, UK, and other liberal market economies (using this term in the sense employed by Hall and Soskice (2001)). The model may be less appropriate, however, for countries in which wage bargains are more likely to be collective. Unions, moreover, influence working conditions as well as wages. Thus, there is evidence that the presence of strong unions reduces the impact of the cost of job loss on effort (Green and McIntosh, 1998), and among European countries there is a correlation between loss of union power and the rate of work intensification (Green and McIntosh, 2001).

If the PBTC hypothesis is true, in the - admittedly extreme - case in which effort levels are set and controlled by unions there are no agency problems between firms and workers: from a single firm's perspective, effort is exogenously given. Having effort levels exogenously determined, moreover, does not block technological progress; it merely weeds out those changes of technique that are profitable only because of work intensification. But if technical progress has been mainly of a power-biased and technically inefficient kind since the late 1970s, then one would expect differences between liberal market economies and economies in which collective bargaining over wages plays an important role: over this period the liberal market economies would be experiencing faster measured productivity growth but also a stronger tendencies toward work intensification and income inequality. This prediction appears to be consistent with the evidence from the last 30 years.

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6 Appendices

6.1 Appendix A: Intertemporal optimization

Consider an infinitely lived agent with instantaneous utility function

$$u(c, e) = c - v(e)$$

Assume that the interest rate r is equal to the discount rate. The time profile of consumption is then a matter of indifference to the agent, and we may assume that consumption matches current income. If U denotes the value function of an unemployed worker, a worker who is currently employed at a wage w faces an optimization problem that can be written

$$\max E[\int_0^T (w - v(e)) \exp(-rt)\ dt + \exp(-rT)\ U]$$

where the stochastic variable T denotes the time that the worker loses the job. Assuming a constant hazard rate, T is exponentially distributed. In a steady state the objective function can be rewritten

$$\begin{aligned} E[\int_0^T (w - v(e)) \exp(-rt)\ dt + \exp(-rT)\ U] &= E\int_0^T (w - v(e) - h) \exp(-rt)\ dt + U \\ &= E(\frac{w - v(e) - h}{r}(1 - \exp(-rT)) + U \\ &= (w - v(e) - h)p + U \end{aligned}$$

where $h = rU$ and $p = E(1 - \exp(-rT))/r = (1 - \frac{\delta}{r+\delta})/r = \frac{1}{r+\delta}$ is an increasing function of the rate of separations δ. Effort affects the firing probability and thus the rate of separations, so the worker's first order condition can be written

$$-v'(e)p(e) + (w - v(e) - h)p'(e) = 0$$

The value function for an unemployed worker will depend on the average level of wages, the rate of unemployment benefits and the hiring rate. With a constant rate of unemployment, the hiring rate q is proportional to the average rate of separations

$$q = \bar{\delta}\frac{L}{N - L} = \bar{\delta}\frac{1 - u}{u}$$

where u is the unemployment rate and $\bar{\delta}$ is the average rate of separations. The risk of job loss gives an incentive for workers to provide effort. But an increased average firing rate does not help the firm unless it raises effort (on the contrary, high labor turnover is usually costly). Since effort is determined by the semi-elasticity p'/p (see the first order condition) it follows that the average firing rate in the economy need not be related to the average level of effort and, secondly, that an improved ability to detect individual effort - a rise in p'/p - may change the average (standard) effort but need not be associated with any changes in the firing rate for workers that meet this changed standard. Thus, it is reasonable to assume that $\bar{\delta}$ is constant. But since average effort is itself determined by $\bar{w}, b$ and u, whether or not $\bar{\delta}$ depends on $\bar{e}$, we have

$$h = h(\bar{w}, b, u)$$

In equilibrium, $w = \bar{w}$ and in order to find the value of h we note that

$$V - U = (w - h - v(e))p \tag{A1}$$

$$U - V = (b - rV)s = \{b - r[(w - h - v(e))p + \frac{h}{r}]\}s \tag{A2}$$

where $s = E(\frac{1-\exp(-rT_u)}{r})$ and the stochastic variable T_u denotes the remaining length of the spell of unemployment of a currently unemployed worker. With a constant rate of separations, random hiring and constant unemployment, the stochastic variable T_u follows an exponential distribution with expected value $ET_u = \frac{u}{1-u}ET$ where $ET = 1/\bar{\delta}$ is the average expected remaining duration of employment for an employed worker. Using (A1)-(A2) and the expressions for p and s ($p = 1/(r+\delta); s = 1/(r + \delta(1-u)/u))$), it follows that

$$\begin{aligned} h &= (w - v(e))\frac{p - rps}{p + s - rps} + b\frac{s}{p + s - rps} \\ &= (w - v(e))\frac{\delta(1-u)}{ru + \delta} + b\frac{(r+\delta)u}{ru + \delta} \end{aligned}$$

Thus, the fallback position is a weighted average of the utility flows while employed and unemployed with the weights depending on the rate of unemployment.

6.2 Appendix B

Let x be the proportion of employed workers in firms that use the new technique, and assume (i) that workers cannot move directly from one job to another and that (ii) equilibrium firing rates are the same in all jobs (this is consistent with differences in monitoring, cf. the argument in Appendix A). Proceeding along the same lines as in Appendix A, the value function for workers in firms using the old and the new technique are then given, respectively, by

$$\begin{aligned} V^o(x) &= (w^o(x) - h(x) - v(e^o(x)))p + U(x) \\ V^n(x) &= (w^n(x) - h(x) - v(e^n(x)))p + U(x) \end{aligned}$$

where

$$p = \frac{1}{r + \delta}$$

In a steady state the value function for an unemployed worker can be written

$$\begin{aligned} U(x) &= E[\int_0^{T_u} b\exp(-rt)\ dt + \exp(-rT_u)\ V(x)] \\ &= E[\frac{b - rV(x)}{r}(1 - \exp(-rT)] + V(x) \\ &= (b - rV(x))s + V(x) \end{aligned}$$

where

$$
\begin{aligned}
V(x) &= xV^n(x) + (1-x)V^o(x) \\
&= [x(w^n(x) - v(e^n(x))) + (1-x)(w^o(x) - v(e^o(x))]p - h(x)p + U(x)
\end{aligned}
$$

and

$$
\begin{aligned}
s &= E(\frac{1-\exp(-rT_u)}{r}) \\
&= 1/(r + \delta(1-u)/u))
\end{aligned}
$$

Hence,

$$
h(x) = [x(w^n(x) - v(e^n(x))) + (1-x)(w^o(x) - v(e^o(x))]\frac{\delta(1-u)}{ru+\delta} + b\frac{(r+\delta)u}{ru+\delta}
$$