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CONTROL, TECHNOLOGY AND THE SOCIAL EFFICIENCY OF TRADITIONAL PRODUCTION:

A Bargaining Model of the Capital-Labour Relationship

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I INTRODUCTION

It has long been recognised that one of the most important features of a production technology lies in its implications for managerial control over the production process. Amongst early writers, Charles Babbage observed: "One great advantage which we may derive from machinery is from the check which it affords against the inattention, the idleness, or the dishonesty of human agents." (1832, p19). His contemporary, Andrew Ure, likewise remarked: "This invention [the self-acting mule] confirms the great doctrine already propounded, that when capital enlists science into her service, the refractory hand of labour will always be taught docility." (1835, reprinted 1963, p 54). In more recent times, the literature of scientific management after Taylor (1911) has built heavily on the principle of technological control, as its radical critics have stressed.[1/] Many current examples involve the extended use of computers, as in the use of robotics in place of man-based technology in car assembly; the introduction of computerised machine tools whose programmes are locked away from their operatives; and the displacement of traditional printing skills by direct-input technology in newspaper production.

The maintenance of control over labour as a consideration in the choice of technology is a central theme of Marxian analysis. This concludes that, as a result, the social productive potential ("the forces of production") is restricted by the capitalist institutional structure ("the social relations of

production").[2/] Traditional theory, by contrast, is silent on the whole question of intrafirm control,[3/] and in the absence of externalities envisages socially efficient production choices by profit-maximising entrepreneurs.

This paper begins by expanding the orthodox production function to incorporate control-related behaviour by employers and workers.[4/] The interdependence of technology and control is next modelled by making the relative bargaining strengths of the "two sides of industry" depend on the choice of technology. The capital-labour relationship is then analyzed in a framework where there is bargaining is over what Aoki (1980,1982, 1984) and others have called "organizational rent". The negotiating process is characterised as a fixed-threat, Nash-bargaining game, with a default, variable-threat game that is played if no agreement is reached. Following previous practice, the variable-threat, default game is styled as a non-cooperative game, in which the disagreement payoffs are valued not for themselves but for their strategic value in influencing subsequent events. Less customarily, however, in this case the disagreement actions are initiated by workers as a strategic ploy to elicit a new technological offer from employers. If this is successful, a new fixed-threat game is played out.

Proceeding in this way, the analysis recognises two levels of threat (exit and conflict) and essentially three strategic options on both sides: cooperation within an agreed bargain, conflict within the firm, and exit. This seems realistic. The

key ideas in the analysis are, first, that by placing constraints on the choice of technology, employers can increase their relative bargaining strength; second, that bargaining strength may be used, by labour in particular, in one of two ways: either to shape the terms of an agreed bargain, or in pursuit of an adversarial strategy; and third, the natural proposition that workers can successfully oppose employers' offers only when there exists a non-conflictual outcome that is preferred by employers (what may be called the "condition for successful opposition").

The model confirms an intuitive, essentially neoclassical result that where technological enhancement of control is possible, and in the realistic case where employers have first-mover advantage by virtue of their unilateral right to precommit technology, they will forfeit technical advantages for the sake of increased control up to the point where its marginal benefit is equal to its marginal, technological cost. However, the analysis also reveals that control-constraints will not always operate but, where control-constrained technology is chosen in equilibrium, a set of Pareto-superior alternatives will be left unexploited. Thus the Marxian proposition of socially inefficient production under capitalism is also confirmed, but in a qualified form.

The analysis yields a number of further insights and answers to questions on which both the traditional and the Marxian models are silent or incomplete. A refined definition of

"control" emerges as the ability of employers or workers to extract organisational rent from the production process. The model also illuminates the circumstances under which workers can successfully challenge employers' control *via* collective action, and hence indirectly casts new light on Freeman and Medoff's (1979, 1984) analysis of the "two faces of unionism". It sharpens the distinction between two senses of the term "cooperation": consent in the (pluralist) context of an agreed bargain, *versus* joint-welfare maximisation in a unitary framework. It clarifies the limits to what may be expected in terms of welfare gains under "alternative" forms of work organization, in particular self-managed and participatory firms. It shows that changes in control parameters deriving from developments in the political and socio-economic environment external to the firm can have allocative effects (*via* their impact on technology) as well as distributional consequences. Finally, it offers an explanation for the coexistence of firms in the same industry with differing technologies and control-types, with direct implications for empirical work.

II CONTROL AND TECHNOLOGY IN A BARGAINING FRAMEWORK

II.1 The Production Function and Bargaining Frontier

Having abstracted from the whole question of intrafirm control, the orthodox production function necessarily lacks variables related to its acquisition and exercise. Implicitly, entreneurial control must be presumed absolute, since output is a single-valued function of any chosen vector of factor input levels;

$$Q = Q(\mathbf{T}), \qquad (2.1)$$

where **T** is such a vector covering materials and factor inputs a of all types and qualities, augmented if desired by continuous or dichotomous variables capturing dimensions of technology and the organisation of production that may not be captured fully by levels of capital and labour input (such as the supervisory, communication and remuneration systems; hierarchical structure; job- batch- or flow-production; and so forth). By assumption, **T** reflects all known technological opportunities, and any given vector **T**′ can be considered a complete description of the technology in use in a particular case.

Control becomes an issue when, as in a variable-threat game, participants in the firm (other than the entrepreneur) can take unilateral action to reduce the firm's output or economic surplus. Expanding (2.1) to allow the degree of control and its distribution amongst the participants to vary, we may write

$$Q = Q(\mathbf{T}, \mathbf{S}), \qquad (2.2)$$

where the S vector reflects the existence of unilateral action sets, and contains variables describing strategic, control-related behaviour. This behaviour includes employers' monitoring intensity, closeness of supervision, authority to reassign tasks within contractually defined limits, threats, lockouts, and so forth. For workers, the relevant variables would include work-effort (or its converse, "shirking" and in-job leisure); strikes; slowdowns; strategic manipulation of the payments-system, work-flow and overtime working; etcetera . In addition, the withholding of information is a strategic option available to both sides. Evidently, most of the elements of S will not be specified fully under the incomplete employment contracts which typify labour markets.[5/] Indeed, the distinction between the elements of T and S very largely turns on what can and cannot be so specified.

In effect, traditional theory suppresses the vector S (as do fixed-threat bargaining models in which there is also no scope for individual action). But the traditional model may be nested in (2.2) by simply normalising the elements of S in such a way that when all are equal to zero ($S = S_0$), there is no recourse to unilateral action or, in other words, what might be called a state of total factor compliance prevails. [6/] This could come about either when factor suppliers have zero bargaining power, as in the traditional, competitive model, or when agreement is reached in a cooperative game. In each case, and given the firm's demand constraints, the production function (2.2) then determines all feasible vectors of variables yielding

utility to employers and workers, denoted Y and Z respectively, which map through the relevant utility functions, V(Y) and G(Z), to define a bargaining set bounded by the bargaining frontier in figure 1.[7/]. Thus the frontier F_1F_1' defines all Pareto-efficient G,V pairs that are attainable with given demand and technological constraints, and with $S = S_0$. It is the set of outcomes in the core on the assumption that agreement will be reached, and the frontier which would be considered in traditional theory.

The existence of a non-empty bargaining space above and to the right of point M in figure 1 may be thought to require an explanation. At M the two sides' utility levels $\bar{V}$, $\bar{G}$ are such as to make them indifferent between working in the firm and elsewhere. Why are payoffs in excess of this not competed away in the relevant input markets? Following Aoki (1980), we take the existence of a bargaining set to depend on a firm-specific <u>organisational rent</u> arising from the "quasi-permanent association" of factor suppliers with the firm, and consequential "economic gains which would not be possible through mere casual combination of marketed factors of production". These gains accrue to the firm from the "unique and lasting interaction of the organisational resources, both human and physical". Moreover, it is "through the acquisition of firm-specific skills and knowledge [that] the employees may be able to exert implicit or explicit bargaining power over the disposition of the organisational rent".

Where such bargaining power exists, we may think of it being exercised in two ways: cooperatively[8/], in the conclusion of an efficient bargaining agreement, or adversarially, via resort to unilateral, surplus-reducing action leading to conflict. (Exit is, of course, a third strategic option available.) Under conflict the condition $S=S_0$ no longer holds, the technically feasible boundary F_1F_1' will not be reached, and the eventual outcome will be at some interior point such as S_1. It will be assumed throughout that conflictual outcomes occur only where workers have non-zero bargaining power. The precise relationship between interior points S and efficient, boundary-point outcomes depends on how the bargaining process is modelled, and is discussed further below.

II.2 A Definition of Control

The term "control" can now be given a more precise definition as the ability of agents to extract organisational rent . Thus points A and B in figure 1 would correspond to full control by employers and workers respectively. Intermediate boundary points such as N_1 may be modelled as efficient bargaining outcomes , determined according to a model of the bargaining process e.g. Kalai and Smorodinsky (1975), Zeuthen-Harsanyi (1930, 1956), or (equivalently) Nash (1950, 1953). In the most familiar of these cases, (generalised) Nash-bargaining, N_1 is obtained by maximising the weighted product of the differences between the players' utility levels and their

"threat points" (in this case, their respective exit levels): max $[G - \bar{G}]^d . [V - \bar{V}]^m$, where the parameters d and m denote relative bargaining strength. Since d and m determine the position of the bargaining outcome along the bargaining frontier and hence, in the present context, the distribution of organisational rent, these bargaining strength parameters may also be thought of as indices of control. Thus control and bargaining strength are related. In conflict situations, relative degrees of control (relative bargaining power) may be thought of as determining the direction and distance of the point S from the relevant boundary point. For these indicate relative, surplus-reducing ability, which may be seen as varying directly with bargaining strength in cooperative negotiations.

II.3 Equilibrium Subject to a Control/Technology Tradeoff

Suppose that, as hypothesised, employers can increase their control by constraining their choice from the available technologies so as to avoid giving workers bargaining power. What this entails in practice is considered in the next section. Suppose further that, as Marxian analysis has it, this involves a technical penalty; hence, a control/technology tradeoff is faced. This may not always be so, and will not be so if technical-efficiency maximising methods are by chance also control-maximising; but that is a special case and cannot be relied upon in general.

Consider first a simple, discrete-choice case with three technologies, T_1 , T_2 and T_3 , where T_1 is unrestricted and the others are control-enhancing for employers, and assume that each has an accompanying control configuration (i.e. set of relative bargaining or control strengths, d_i, m_i, $i = 1,2,3$) Let F_1F_1' in figure 1 be the frontier associated with T_1 , and N_1 be the Nash-bargaining outcome for $d = d_1$, and $m = m_1$, but let S_1 be the conflict outcome if there is no agreement. As in Nash's arbitration scenario, S_1 is located on a line of equal absolute slope but opposite sign to the frontier at N_1. No arbitration is in fact expected under the present approach, but this relationship between the points is nevertheless retained, because the players' relative capacity to inflict damage is thereby kept proportional to relative bargaining power, which seems reasonable. For the same reason, the distance from S_1 to N_1 is also determined by relative bargaining strength. With technologies T_2 and T_3 there is, ex hypothesi , a technical loss so that the underlying, objective production frontier shifts in towards the origin in commodity space. Feeding through the players' utility functions, this effect is then captured in figure 1 by a shrinking of the bargaining space to the areas bounded by F_2F_2' and F_3F_3' respectively. The Nash-bargaining and conflictual outcomes in these cases are N_2, S_2 and N_3, S_3 respectively. Because employers' control is greater under technology T^2, N_2 is distributionally more favourable to employers than is N_1 under T_1; hence N_2 is located higher on F_2F_2' than is N_1 on F_1F_1'. Similarly, S_2 is located

proportionately closer to N_2 than is S_1 to N_1, reflecting the reduction in workers' relative control-power. Since T_3 is more control-enhancing than T_2, N_3 is distributionally more favourable still than is N_2, and S_3 is again proportionately closer to N_3.

We assume that employers have first-mover advantage in determining technology. This is realistic and, indeed, a hallmark of the traditional organisation of production; typically, owners can unilaterally precommit the choice of product and production methods, as a consequence of their differentially advantaged access to technical know-how and/or financial capital.[9/] However, in making their choice, the employers must take into account the workers' subsequent choice of strategy, and hence they face uncertainty over whether there will be agreement or conflict. Employers will expect workers to oppose where it is in their interests to do so; there is no "loyalty" in the model in the sense that would require them to do otherwise. However, as we shall see, workers will be able to oppose an employer's offer <u>successfully</u> only where there exists an alternative, non-conflictual outcome that is preferred by employers. With full information and rational expectations on both sides, overt conflict should never occur. In practice it is to be expected to the extent that this is not the case. Given employers' discretion to precommit technology, the relevant concept of equilibrium is a technological choice, T, which workers have no incentive or capacity oppose.

Workers clearly have no incentive to oppose the unconstrained technology T_1, as there is nothing for them to gain by so doing. Rational behaviour thus requires that they exert their bargaining strength m_1 in the context of an agreement. Consequently S_1 plays no part in the analysis and, barring accidents, the employer can expect an equilibrium at N_1.[10/] Under T_2, however, it is rational for workers to force the conflict outcome S_2 in order to induce the employers to switch to the unconstrained technology. This is a credible stance, because S_2 is inferior to N_1 ($S_2 < N_1$) for employers and, as we have seen, N_1 is available. Hence, anticipating initial conflict and an eventual equilibrium at N_1, the employers will not choose T_2. But workers will not be able to block the even more control-enhancing technology T_3 by this strategy, because for employers S_3 N_1. (Note that though $S_3 < N_2$ for employers, N_2 is not a credible offer for workers to make since, by reneging on the agreement once there, workers can force equilibrium at N_1, by the process just described.) Thus equilibrium in this discrete-choice case involves the choice of T_3 and, since workers once again have no incentive to oppose, equilibrium will occur at point N_3. This is a private optimum for employers since V is maximised given the available control-technology options. It is also privately optimal for workers, offering maximum accessible G <u>given</u> the employers' ability to precommit technology. But there remains a set of unexploited Pareto-superior outcomes in the shaded area to the north-east of N_3 in figure 1. Thus the outcome is socially inefficient or, in Marxian terms, "irrational". The

necessary and sufficient condition for a control-constrained equilibrium is evidently that there exists some T_c such that $S_c > N_u$, where the subscripts c and u denote the constrained and and unconstrained technologies. When $S_c = N_u$ employers will be indifferent as between T_c and T_u.

Where, as here, economic agents face unexploited mutual gains, orthodox theory generates strong expectations that some market or non-market institution will emerge that will enable them to be secured; under the economic Darwinism that underlies the theory, efficiency will out. The difficulty in the present case lies in ensuring that <u>only</u> Pareto improvements are allowed: in the case of figure 1 that V_3, G_3 remain guaranteed minimum payoffs for the two sides. The scope and limitations of "alternative" forms of work organisation in this regard are reviewed in section 4.1. The other main solution might be seen to lie in arbitration; employers and workers would appeal to some governmental or other independent umpire to ensure fair play. But it is easy to see why this is unlikely in the present case. First, it would be very slow and costly if an independent arbitrator had to be routinely convinced as to the payoffs under existing <u>and hypothetical alternative</u> or new technologies. Second, workers would be unlikely to accept private-sector provision of arbitration services, on grounds of pro-employer bias or subornation, while widespread resort to continuing government arbitration would be politically risky for employers; admission of the need for official intervention would greatly undermine the argument against social ownership of the means of

production. Thus there would seem to be no economic institution compatible with capitalism that would be capable of securing the present, unexploited mutual gains.

Extension to the case where there is a continuous tradeoff between control and technical advantage is straightforward. We will now have a locus of points N and of S tracing the Nash-bargaining and conflict outcomes, as in figure 2. The general shape of these loci is conjectural. They may reach an internal maximum, as shown, but could alternatively rise monotonically from their starting points N_u, S_u to the point of absolute employer-control, P, on the vertical through G. In the former case P could be either above or below the level of N_1. Alternatively, they could slope downwards in the direction of the origin, in which case the unconstrained technology will always be chosen, and socially efficient production will prevail. Thus the scope for technological control-enhancement is also limited by technical factors. All depends on the characteristics of the technologies available in a given case, and their control implications. Over time, we would of course expect innovatory effort directed at control-enhancement as well as pure <u>technical</u> advance.[11/]

In the case shown in figure 2 equilibrium is at N^*, the Nash-bargaining point which maximises V subject to $S^* > N_u$. At this point the marginal benefit of control-enhancement to employers is equal to the marginal, technical cost of securing it. By the use of adversarial tactics workers can block

technologies outside the range SS` on $\overline{PS}_u$. At both S and S` employers will be indifferent between the conflict outcomes under the respective, constrained technologies and the unconstrained Nash-bargaining solution. In a general equilibrium framework N^* in a given firm must be consistent with what is happening elsewhere. With uniform preferences on both sides, and in the absence of market frictions, this would require that the associated utility levels V^*, G^* conform to their "normal", economy-wide levels. Heterogenous preferences and/or market frictions would however allow some interfirm variation in outcomes and payoffs. Note that although N^* may to this extent be thought of as market determined, it is not to be confused with point M. The latter, it will be recalled, represents the most that can be obtained from pure market coordination of production, whereas N^* reflects the additional benefits of the existence of firms.

III HUMAN CAPITAL AND THE CONSTRAINTS ON THE CHOICE OF TECHNOLOGY

Previous writers, including Aoki (1984), have implied that if employers wish to increase their control by constraining their choice from the available technologies, this will mean avoiding production methods involving high levels of firm-specific human capital, since it is from this that employees' bargaining power largely derives.[12/] This is not wholly obvious a priori , since their reservation wages will also presumably be higher than otherwise, thus reducing the credibility of bargaining threats. However the long history of "scientific management", with its emphasis on deskilling and the division of labour, supports the Aoki position, which will be accepted here. Ultimately, the question is of course susceptible only to empirical resolution rather than to a priori speculation.

The practical details of what is entailed are well documented in the literature deriving from both Taylor (1947) and from his latter-day radical opponents (notably Braverman, 1974; Gintis, 1976; and Roemer, 1979). In the original, Taylorist design, the principal elements are deskilling via fine division of labour, precise job-descriptions, and close control of work effort through machine-pacing or hierarchical supervision. Human capital development is minimised, the cost of replacing untrained labour is low, and "hire and fire" policies are therefore viable options. The choice of technique and

direction of R and D effort are governed by implications for control over the workforce as well as purely technical considerations, and piecework earnings or similar individual incentives may be used to motivate workers.[13/]

In recent years, however, some of the traditional employer-control tactics appear to have been discarded in favour of more subtle methods. In particular, modest levels of profit-sharing or value-added bonus systems have sometimes been substituted for individual incentives, and found to be more effective because they are less prone to manipulation by workers. Similarly, firms have found that "human relations", and even a measure of participation, can be deployed to increase the acceptability of employer control. However, in the case of participation where employer control remains the aim, care will be taken to ensure that there is no serious erosion of management´s prerogatives over confidential, strategic information, which is central both to their capacity to control and to their status.

Thus, the technological choices to be avoided in the pursuit of control are those from which workers could derive "implicit or explicit bargaining power" via the acquisition of firm-specific skills and knowledge. The technical penalty which it was earlier assumed this might entail now emerges as having an additional element (over and above the direct costs of increased surveillance for a given technology): the foregone productivity and welfare gains which might otherwise be obtained by developing the potential human capital of the workforce

Workers do not necessarily receive less than the value of their marginal products, but the choice of technology and level of investment in training, etc., is such that their marginal products are less than they might have been.

IV IMPLICATIONS

IV.1 Social Efficiency under Traditional, Self-Managed and Participatory Organization

As has been pointed out, the control-constrained equilibrium is socially inefficient, leaving unexploited a set of Pareto-superior alternatives. Thus, there is a social efficiency loss, the origin of which lies in employers' first-mover rights.[14/] Note that, given an established, traditional equilibrium, codetermination and other forms of participation will not generally in themselves enable a move to mutually preferred outcomes, (though they may have served as an institutional mechanism for efficient bargaining permitting the relevant, control-constrained bargaining frontier to be reached; c.f. McCain,1980 and McDonald and Solow, 1981). The problem is that outcomes cannot easily be constrained in practice to allow only Pareto improvements. Thus, once employers are induced to relax the technology constraint, they become vulnerable to workers' reneging on the agreement and forcing the unconstrained equilibrium N_u, which is inferior for employers. This may account for employer opposition to the legal imposition of participatory provisions, as in Britain with respect to the EEC "Vredeling" proposals; or evasion of legal provisions, as by the manipulation of firm size to escape application of the 1976 codetermination law in West Germany. A possible solution may lie in the combination of participation with profit-sharing (c.f. Cable and FitzRoy, 1980). Thus, if profit-sharing can engender a

sufficient degree of interdependence of workers´ and employers´ utility (or in the language of the current debate on profit-sharing in the UK, sufficient "idenfication of employees with the interests of the firm"), employers may regard the previous payoff associated with the non-participatory, constrained equilibrium, at point N^* in figure 2, as a guaranteed minimum. However, it must be remembered that profit may be only one argument in the employers´ utlity function. Moreover, the extent of profit-sharing required to engender the required degree of identity of workers´ and employers´ interests may exceed acceptable bounds for shareholders. So it is not certain that even the participation-profitsharing combination will be effective in exploiting mutual gains.

The case is different under self-management, e.g. in a producer cooperative where workers own the firm´s capital and/or form its management. Here the relative bargaining power of capital and labour is irrelevant. Cooperators may be modelled as maximising joint welfare: $J = J(G,V)$, and the control parameters d,m, in the pluralist case are replaced by the relative weights of G and V in the J function.[15/] Thus there is no reason for PCs to apply control constraints. At first sight this seems to imply that PCs will always operate at an unconstrained boundary point (determined by the relative weights of G and V in J), and hence lead to socially efficient production. But there may exist other sorts of technology constraint for a cooperative, e.g. avoiding production methods which would involve social relationships incompatible with cooperative

ideals. If so, the effective frontier will again lie within the unconstrained frontier, and it is a matter for empirical enquiry rather than a priori speculation as to whether the social efficiency losses under cooperatives will be greater or less than those under traditional organization. In general, however, the theoretical framework here predicts different outcomes under self-management and capitalist production (because the constraints differ), whereas the prevailing Ward-Domar-Vanek paradigm generates predominantly "equivalence" results.[16/]

IV.2 The "Two Faces of Unionism"

In a number of recent publications Freeman and Medoff (1979, 1984) have counterposed two alternative views on the role of trade unions -- as protagonists and monopoly suppliers of organized labour, and as its "collective voice" respectively -- with markedly different welfare and policy implications. Viewed from the standpoint of orthodox theory these are more or less discrete alternatives; there is room for only one or, if not that, there is at any rate no general explanation of when each should apply or dominate. In the present analysis, by contrast, the model explicitly calls for two distinct roles, not wholly unlike those of Freeman and Medoff. Thus union behaviour may be required either to "cooperate" (in the pluralist sense) in the conclusion of an agreed bargain, i.e. serve as an instrument for "efficient" bargaining, or to orchestrate adversarial behaviour

in a conflict situation. To be sure this is little more than common sense. However, what the model adds is that the trigger for these alternative modes of behaviour lies in the employers' technology-precommittment strategy, and this, together with the previously enunciated principle of successful opposition, offers a new insight in the theory of union behaviour.

IV.3 The Direction of and Impediments to Technical Progress

Like traditional theory, the present model is static and takes extant technology as given. Unlike traditional theory, however, it gives theoretical underpinning to much previous descriptive and empirical literature alleging bias in R and D activity towards control-enhancing as well as more technically efficient new methods. Thus employers, who generally have unilateral control over R and D policy, will be seeking not just to shift the underlying, objective production frontier, but to do so in a control-increasing manner: to seek unconstrained new technologies with higher "natural" d/m ratios. Projects with adverse control implications will conversely tend not to be pursued or to be dropped. Now there is no necessity that, scientifically speaking, this is the natural way to go. It could be that greater advance would be available from a given R and D budget deployed in other directions. If so, there will be a dynamic social loss over and above the static loss identified

earlier.

The model also casts some light on the circumstances when worker resistance to new methods is to be expected. According to the principle of successful opposition, this will occur when they are part of an employers' precommittment strategy where the conflict outcome is inferior, for employers, to a credible, cooperative outcome under a technological alternative preferable to workers. Otherwise, workers will accept new methods in the context of an agreement.

IV.4 External Determinants of Control

In focussing on the connection between technology and control within the firm, external determinants of the relative bargaining strengths of workers and employers have implicitly been held constant. In reality these strengths will vary with, for example, the level of macroeconomic activity and demand for labour; the levels of unemployment and other social security benefits; and, especially, changes in labour law (on picketing, striking rights and procedures, police activity, liability for damages, etcetera).

The impact of external determinants such as these can be observed in the model in the following way. First, for any given frontier, an environmental shift conducive to increased employer

control will move the relevant point N along the frontier in the direction of the vertical axis. As a result the curve PN_u will shift upwards. This is a distributional effect which is fairly obvious and hardly requires a model to see. But, in addition, each relevant point S (the conflict outcome) will become closer to its respective N; the curve PS_u also rises, and this reduces the set of technologies labour can block out. Hence there is also an allocative/technology effect, and this is not obvious.

IV.5 The Coexistence of Alternative Firm Types

We have already seen that, in the present model, producer-cooperatives and traditional firms can coexist in equilibrium, and would in general exhibit different technological and other characteristics. These derive partly from differences of maximand, and partly from differences in the operative constraints. In addition, the possibility of a multiple equilibrium within the traditional firm sector can easily be shown. This occurs if the curve PN_u becomes horizontal at or above N_u. Then, employers will be indifferent over a range of outcomes with differing degrees of inbuilt control, but which labour cannot successfully resist (for employers the technical penalty for higher degrees of control is exactly offset by the increase in their sectional share). The first "offer" by employers within this range will

become the equilibrium. Amongst firms distributed over this range we would observe differences in the choice of technology, in the input-vector (especially with respect to the quality of the worforce and hence in the payoff to workers) and in production methods, but no (net) differences in employers' payoffs or in indicators of conflict. In the formal model the requirements for multiple equilibrium are quite severe. In practice, however, with uncertainty on both sides as to the exact bargaining strengths under given technologies, and hence of the relevant points N and S, PN_u may need to be only approximately horizontal over some range for a multiple equilibrium to occur.

IV.6 Empirical Work

The fact that the model admits of a dispersion of firm types in equilibrium provides the basis for empirical work. (Though as always we may expect also to observe disequilibrium cases and, in particular, conflict situations which occur as agents without full information and/or rational expectations feel for the underlying equilibrium outcomes.) Given an appropriate sample, and prior information on variations within it across firms in the degree of their preoccupation with control, we can then test for systematic differences in payoffs and in firm-specific characteristics, and for whether these are important in the production process.

Some results for a sample of 61 firms in the West German metalworking industry are reported in a companion paper (Cable, 1987). A prior partitioning of the sample in this case is based on (Guttman scales of) the degree of employee-participation in decision-making as observed in primary survey data. Significant structural differences are found as between subsamples, which are broadly as expected in the light of the foregoing arguments, and which subsequently prove significant in (production function estimates of) the production process. As well as contributing to the empirical literature on participation itself, these results represent tests for the existence of binding control-constraints as postulated in this paper.[17/]

V. CONCLUSIONS

Traditional theory takes no account of the fact that employers may be able to enhance their control over the production process, and their relative bargaining power *vis-a-vis* workers, by restricting their production choices from among the available technologies. Where this is so, where employers have the unilateral right to precommit production technology, and where workers can successfully block precommittment strategies only if there is a credible, negotiable alternative which is preferable to employers than is the conflict outcome under the blocked strategy, it can be shown that traditionally organised production will be socially inefficient, leaving unexploited a set of Pareto-superior outcomes. Associated with this social loss is likely to be a failure to develop potential human capital among the workforce. Given the likely shape of the relevant functions (specifically, the gradient of the locus of Nash bargaining equilibria for increasing degrees of technological control- enhancement), we may in general expect a relatively large reduction in workers' utility for a comparatively small increase in employers' utility. Moreover, since workers will generally be able to block mild degrees of control-enhancement, it will tend to be taken to considerable lengths where it does occur. Codetermination and participation "schemes" are unlikely to permit realisation of the potential, mutual gains in traditional firms unless accompanied by high levels of profitsharing or workers' capital. Control-related social inefficiency would not be expected in producer

cooperatives which, however, may be subject to other kinds of constraint. In the model used to demonstrate these points it is easy to see how unions may be called upon to adopt either adversarial or cooperative roles according to circumstance; how technical change may be biased towards control-enhancing as well as, or instead of, purely technical advances; how external determinants of intra-firm bargaining power such as labour law can have allocative as well as distributional consequences, *via* their effects on the range of technologies which workers can successfully preclude; and how firms with differing degrees of control-orientation may coexist in the same industry.

FOOTNOTES

1/. See, for example, Marglin (1974), Braverman (1974), Edwards (1979), Lazonick (1982), and Melman (1983).

2/. For a recent analysis see Bowles (1985). Introducing an additional function for the costs of extracting workers' effort ("labour") from hired labour inputs ("labour power") into the Walrasian system of production and cost functions, Bowles is able to derive three central Marxian propositions: the social inefficiency of capitalist production; the fostering of divisions among workers; and involuntary unemployment.

3/. Implicitly, control is assumed costless and everywhere complete. Choice of technology is uninhibited by considerations of control, and output remains a single-valued function of input quantities, whatever technological choice is made. Thus, technology and control are treated as mutually independent.

4/. We deal throughout in terms of a two-person game between the "two sides of industry": employers (i.e. owners and their agents, (top) managers) and workers. Thus, problems of goal-conflict and intra-group coordination are suppressed. Reduction to two-persons is a standard simplification of cooperative games, which "eliminates any complications due to allowing a myriad of coalitions" (Friedman, 1986). In the case of employers, a transactions-cost efficient reconciliation of owners' and managers' objectives is assumed to have taken place within the agency framework developed by Jensen and Meckling (1976).

5/.See, e.g. Simon (1951) and subsequent literature.

6/. Zero is clearly the natural compliance value for some elements of S, such as strikes and lockouts. Others, however, may have non-zero equilibrium levels for a profit-maximising firm even with total compliance (e.g. optimal monitoring intensity will presumably be positive). Under the normalisation procedure, variables of the latter type will be entered as deviations from their non-zero, optimising levels.

7/. The utility vectors **Y** , **Z** will include the usual monetary rewards (residual profits, , and contractual wages, w, as in orthodox models), together with firm-specific wage and salary supplements in the form of shares in organisational rent (Aoki, 1980). For greater realism and insight we may also include non-pecuniary benefits such as perquisites; job-security (the expected duration of employment); job-satisfaction arising from the execution of assigned tasks and from their nature and variety; mental and physical effort; the exercise of discretion and control <u>per se</u> , working conditions; and so on, so that the participants' utility depends not only on the value of the firm's payoff, but also on the way production is organised and carried out (the axiom of neutrality of transformations is relaxed).

8/. Note that "cooperate" is used here in the first (pluralist) of the two senses mentioned in the introduction, and does not imply joint-welfare maximisation. The outcome under this alternative meaning is considered in section IV. Both meanings are of course consistent with the game-theoretic notion of "cooperation": the ability of agents to communicate and make binding agreements.

9/. Though there is of course nothing to prevent them setting up, for example, as a cooperative if they wish. We will return later to the question of when, if ever, the cooperative choice is to be expected. If workers accumulate know-how and/or capital, they can either form coops or become employers, as some evidently do over time. (The distinction between employers and workers in the model relates strictly to function rather than persona .)

10/. Note that this is the case despite the fact that there may be a further set of worker -control enhancing technologies, with a workers-utility-maximising equilibrium, analogous to N^*, but in this case in the region below and to the right of N_u. But it is easy to show that the conflict outcomes for these technologies will lie below S_u. Hence their Nash-bargaining points are not credible, and employers could not be induced to introduce these technologies by worker-opposition to the unconstrained technology.

11/. The existence of control-bias in R and D has long been reconised, as can be seen in the quotation from Ure towards the the beginning of this paper. The contribution of the present model is that, unlike traditional theory, it shows why this might be (see also section IV.3).

12/. Aoki writes: "The employees are considered to embody skills and knowledge more or less specific to the firm as a result of quasi-permanent association with it. The employees, in cooperation with assets supplied by the stockholders, can produce some economic gains which would not be possible through mere casual combination of marketed factors of production. These economic gains accrue to the firm from the unique and lasting interaction of the organisational resources, both human and physical, and may be termed the organisational rent. Through the acquisition of firm-specific skills and knowledge, the employees may be able to exert implicit or explicit bargaining power over the disposition of the organisational rent ."(Emphasis added). Aoki goes on to cite supporting statements from Marshall and Hayek. Further emphasis on the importance of firm-specific skills may be found, for example, in the literature on internal labour markets after Doeringer and Piore (1970), and in the analysis of the employment relation by Williamson, Wachter and Harris (1975).

13/. Though Bradley and Gelb (1983) argue that resort to payment by results actually represents a failure of the supervisory system.

14/. And ultimately depends on employers' differentially advantaged access to know-how and financial capital (or as Marxists would say, the prior accummulation of capital). Over time there can, of course, be entry to the ranks of employers, amongst others by workers, as discussed in footnote 8.

15/. Note that "cooperation" is used here in the second, unitary sense given in the introduction. For an integrated treatment of unionised-capitalist and self-managed firms in a bargaining framework, see Ben-Ner and Estrin (1985).

16/. See, in particular, Dreze (1976) and, for a recent survey, Ireland and Law (1982).

17/. Note that no causal flow from participation to the observed differences is implied; the participation variable is acting strictly as an indicator of the strength of control-orientation.

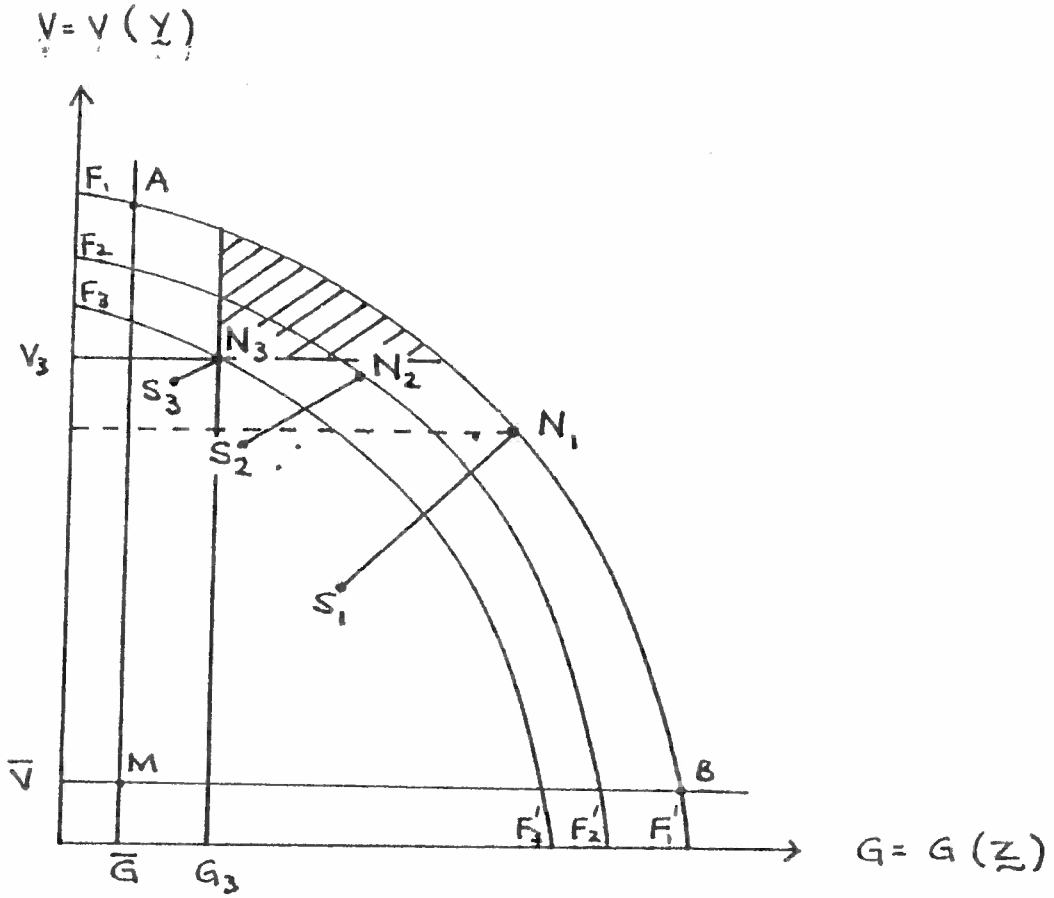

Figure 1 : Discrete Technologies

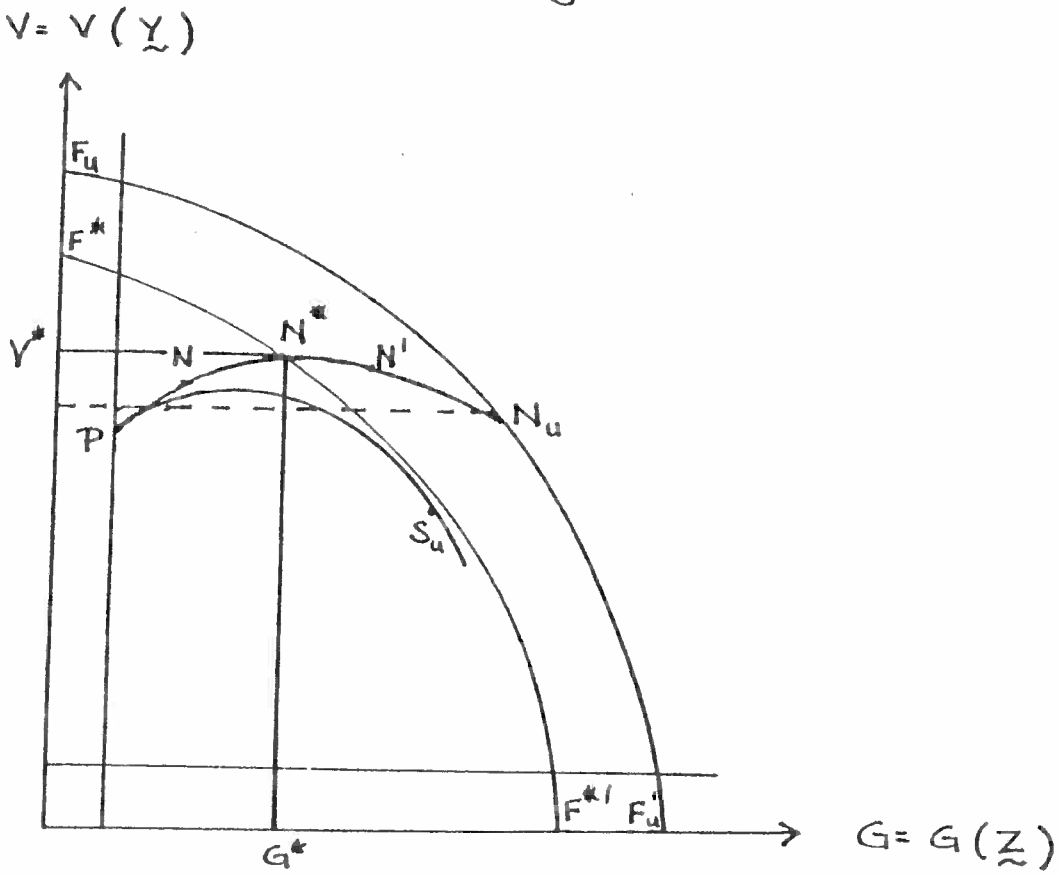

Figure 2 : Continuous Tradeoff

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