RECIPROCITY IN THE PRISONERS' DILEMMA: A New Look at Profit-Sharing, Participation and Work Organisation

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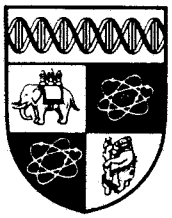

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I. INTRODUCTION

Recent years have seen a continuing development of participatory work-practices in many countries, from simple profit-sharing remuneration systems, through employee share-ownership plans (ESOPS) and varying degrees of workers' involvement in decision-making, to the ultimate participatory form, the producer cooperative. On the other hand, we also observe tendencies towards the reassertion of traditional authoritarian management, for example under Thatcherite policies in Britain. We suggest that the coexistence of these divergent tendencies can be best understood, and the relative efficacy of participatory vs traditional work organisation assessed, when seen in the context of a repeated Prisoners' Dilemma (PD) game. Thus we offer a new perspective on issues discussed inter alia in a series of papers in this journal, following Williamson's (1980) contribution to its inaugural issue.

It is both intuitive and supported by common observation that, as in a PD game, workers and employers can become locked into low-productivity low reward conflict outcomes, even though mutually preferred cooperative outcomes are available. But previous PD analyses of work/employment issues in the economics literature have been few, and limited to individuals' choices of effort-level for a given technology and organisational context (Sen, 1973; Leibenstein, 1982; Stark, 1987). In section II we suggest that the problem can operate in a more fundamental way, involving the choice of technology and organisation itself. The argument turns on a control productivity trade-off: the notion that by accepting self-imposed (productivity-lowering) constraints on the choice of technology,

controlling employers (or workers) can increase their control over production and, ultimately, their share of the firm's economic surplus. Though neglected by orthodox neoclassical theory, the importance of technological control over the production process was recognised early in the industrial era (Babbage, 1832; Ure, 1835) and is central to Marxian and more recent radical economic thought.[1/] Analysing the trade-off in an informal, bargaining-theory framework, we readily obtain the characteristic PD pay off matrix.

Seen in the context of an underlying prisoners' dilemma, the focal aspects of participatory and traditional work arrangements now become those bearing on possible escapes from the PD problem. Section III reviews the alternative routes which have been identified in the literature, focussing in particular on TIT FOR TAT cooperation, which has consistently emerged as an evolutionary stable strategy (ESS) in repeated PD games (Axelrod, 1984; Dawkins, 1976). Reconsideration of participatory work-organisation in the light of these alternatives in section IV de-emphasizes features like trust-building and the ability to make binding commitments which have received attention in the previous literature, and highlights other new considerations, in particular those concerned with the durability and frequency of interaction between workers and employees. Our principal conclusions are summarised in section V.

II. THE PRISONERS' DILEMMA AT WORK

In an early PD-analysis of the work employment issue, Sen (1973) considered an interpersonal free-rider problem in a producer cooperative setting, where the system of rewards is according to need

(not work), and individuals are faced with the choice whether or not to work hard. More recently Leibenstein (1982) and Stark (1987) have broadened the context to a worker-employer game in conventional firms, introducing into the analysis a range of tactical actions on the part of the firm (working conditions, salaries, security and so forth), in addition to employees' effort-level choices. In each case, individually-rational maximisation is the dominant strategy, even though the outcome is Pareto-inferior to the cooperative payoff. But the analysis throughout is of productivity variation in a given technologicial and organisational setting. Serious and real enough though the PD problem at this level may be, we argue that it can go deeper, touching the underlying choice of technology and organisational design.

Consider a two-person game between workers and "the firm" where what is at stake is control over the firm's policies and, ultimately, over the distribution of what Aoki (1980) terms its organisational rent, i.e. the "economic gains which would not be possible through mere casual combination of marketed factors of production ... (and) ... accrue to the firm from the unique and lasting interaction of the organisational resources, both human and physical", (op cit p.600).[2/] As in a variable-threat game (but not orthodox theory), assume both sides can take unilateral action to reduce the firm's output or economic surplus. For the firm, this action could include threats, lockouts and so forth; for workers, it includes shirking, strikes, slow-downs, and strategic manipulation of the payments system ("rate-busting"), of the work-flow and of overtime, and the like.

Let the players' utility functions be $V = V(\underline{Y})$ for the firm, and $G = G(\underline{Z})$ for workers, where $\underline{Y}$ and $\underline{Z}$ are vectors of variables yielding utility to employers and workers respectively. In practice, the vectors $\underline{Y}$ and $\underline{Z}$ would contain many elements, but for illustrative purposes we may write $\underline{Y} = (\pi)$ and $\underline{Z} = (w, L)$, where Π, w and L denote profit, wages and employment. Assume that there is an underlying, well-behaved, concave production function: $Q = Q(\underline{X})$, where the $\underline{X}$ vector contains not only factor-input variables of the usual sort, but also variables reflecting the existence of the players' unilateral action sets described above $(\underline{A}_w, \underline{A}_f)$. The production function $Q(\underline{X})$ defines all feasible vectors $\underline{Y}$ and $\underline{Z}$ which map through the utility functions $V(\underline{Y})$ and $G(\underline{Z})$ to define a bargaining set bounded by the curve FF' in figure 1. As long as there is no resort to unilateral action, so that the relevant variables in the vectors $\underline{A}_w$, $\underline{A}_f$ do not come into play, FF' is the Nash-Zeuthen-Harsanyi efficient bargaining frontier, which defines all Pareto-efficient G, V pairs that are attainable with given demand and technological constraints; it is the set of outcomes in the core on the assumption that agreement will be reached. $\bar{V}$ and $\bar{G}$ represent (exit-) threat-point utility levels for the firm and workers respectively (at which they are indifferent between remaining with the firm and transferring elsewhere). The existence of a non-empty bargaining set above and to the right of point M reflects the presence of organisational rent, and its dimensions indicate the magnitude of this rent. Cooperative, efficient-bargaining outcomes will lie between A and B on FF', according to the players' relative bargaining strengths, and the nature of the bargaining process.

Now consider a control-technology tradeoff, for example in the case of automobile assembly. It may be argued that with a fully cooperative workforce, auto production would be most efficiently carried out using mainly human labour, (on account of its superior flexibility, reasoning and reaction capabilities, and its range of capabilities)[3/]; but robots are nevertheless substituted widely for workers by employers, to avoid ceding control-power to workers which their position in the human-based technology would grant.[4/] Thus, there is a technical penalty in the form of a productivity loss relative to the control-unconstrained technology, but the constrained choice is nevertheless preferred if this loss is more than offset by an increase in the share of the firm's organisational rent accruing to (in this case) employers. Clearly such tradeoffs need not be universal, and will not be faced if technical-efficiency maximising methods are by chance also control-maximising. But that is a special case which cannot be relied upon in general, and we posit the tradeoff as characterising at least a non-trivial set of circumstances.

Productivity losses will show in figure 1 as inward shifts in the position of the frontier FF', and redistributions of organisational rent (under cooperative agreements) as a movement around the relevant frontier. Suppose that point N is the cooperative outcome for the control-unconstrained technology. On our assumptions FF' is the utlimate attainable frontier, and the position of N on it reflects the relative control implications, and hence bargaining strengths, inherent in this technology; if, for example, we envisage a (generalised) Nash-bargaining process, the technologically-determined bargaining strengths are captured by the parameters δ and μ in the maximand: $(V - \bar{V})^{\delta} \cdot (G - \bar{G})^{\mu}$. Next consider the technology-control choice from the employer's point of view, assuming

for the moment that he has a free hand. Progressive control-constraints shift the frontier inwards but move the equilibrium around successive frontiers towards the V-axis. If the process is continuous and subject to diminishing returns, a locus of equilibrium points E will be traced out, possibly with an interior optimum for the employer at E.[5/] By analogous reasoning, a corresponding optimum from the workers' point of view will exist at, say, W^* . At both these points the firm is being run at a fairly high level of technical efficiency, with correspondingly high total payoffs that are, however, distributed assymmetrically in favour of one player. But these are clearly "temptation" outcomes and likely to prove illusory, for they require cooperation on the part of the disadvantaged player. In our scenario this means no resort to unilateral action to damage the opponent, which will not be forthcoming if, by taking such action, an interior outcome such as I can be forced. Thus, the individually rational choice for both sides is to fight for control over the firm's policies, even though the outcome at I is Pareto-inferior to the cooperative outcome at N .

Suitably calibrated, the four outcomes in figure 1 yield the payoff matrix in table 1, which clearly has a PD structure.[6/] As is well known, 'control' is the mutually dominant strategy under individual rationality assumptions in a one-shot game; whatever the other side chooses, it is always better for ech side to choose control. Backwards induction shows that the conflict outcome is also on the equilibrium path at every point in finitely repeated games.[7/] However experiments suggest that in practice players often cooperate, at least for a while, and end up with payoffs strictly greater than under equilibrium pay. Even in one-shot games there can be surprisingly

high levels of cooperation (Marwell and Ames, 1981).[8/] In repeated games, strategic cooperation frequently evolves in the form of Rapoport's TIT FOR TAT: initial cooperation which is continued only if the opponent cooperated at the previous stage. Axelrod (1984) reports that this simple strategy won both the first and the second rounds of his computerised PD tournament against more than sixty entries (even though, in the second round, the results of the first were revealed), also winning 5 out of 6 major variants of the second round, and coming second in the sixth. Moreover, these results are consistent with those of computer simulations in mathematical genetics reported by Dawkins (1976), in which "retaliator" (essentially TIT FOR TAT) emerged as the evolutionarily stable strategy (ESS) against four others (hawk, dove, bully and prober-retaliator).

Kreps, Milgrom, Roberts and Wilson (1982) show that such cooperation is consistent with rational, self-interested behaviour until the last few stages of repeated games if either it is common knowledge that the opponent is not playing TIT FOR TAT, or there is two-sided uncertainty over the stage payoffs (and hence over the opponent's incentive to renege). Incomplete information of this kind is not unlikely in the complex, work-organisation game under consideration. However, Kreps et al's resort to defects of information to reconcile observed behaviour with orthodox theory is less than wholly convincing. The alternative possibility is that, being social animals subject to various kinds of social conditioning and shaping of their behaviour, the players actually depart from individual self-interest. Signs of this may be found in the experimental evidence. For example, Collard (1978, p 41) cites Rapoport and Chammah's (1965) early finding of more variation between

pairs of players than within pairs; the favourable effect of communication or cooperation; and increasing cooperation when the genders are mixed. Collard himself stresses the importance of cooperation-enhancing factors such as close contact between the players, and subscription to a common ethic.

When considering the impact of such social determinants of behaviour in the PD situation, it is helpful to recall Sen's (1987) separation of the three underlying assumptions that are compounded in the orthodox, individual rationality principle. These are: (i) self-centered welfare (only own-consumption enters the utility function); (ii) self-welfare goals (own utility is the maximand); and (iii) self-goal choice (behaviour is governed only by utility maximisation, ignoring, for example, mutual interdependence with the actions of others). With this in mind, we can proceed to consider four possible escape routes to cooperation in the prisoners' dilemma: socially modified payoffs; altruism (or Sen's "sympathy approach"); reciprocity; and "golden rule" morality (which is here understood, following Leibenstein (1982), as doing to others as we would wish them to do to us).

III. SOCIAL INTERVENTION, ALTRUISM, RECIPROCITY AND GOLDEN RULE

Socially modified payoffs

One of Axelrod's main recommendations for promoting cooperation is to alter the payoffs (in particular so that the temptation payoff T no longer exceeds the reward for cooperation R (table 1)). Laws punishing tax-evasion in the taxation/public

expenditure game are given as an example (Schelling, 1973). Such laws represent a particularly tangible form of social conditioning which, if successfully drafted and enforced, can induce individuals to behave in a way other than that which self-interest with respect to the unmodified (i.e. penalty-free) payoffs would dictate. Less formal, but perhaps equally powerful social modification of payoffs could similarly occur via the engendering of guilt and shame at having yielded to temptation against prevailing social norms, and the award of social approbation and esteem for remaining within them. We can model these effects in either of two ways. One is to relax Sen's assumption (i), incorporating the social punishments and rewards in the individual utility function, which is then maximised according to (ii) and (iii). Alternatively, we can assume (i) remains unchanged, but relax (ii) and/or (iii), thereby admitting the possibility of socially-prompted behaviour that is independent of own-welfare. From a behavioural point of view it makes no difference which we choose; the predicted response is the same. But the welfare interpretation of the outcome is clearly different.

Altruism

Arguably the only non-socially determined case of altruism is the genetically governed behaviour of individuals towards their own-game carrying kin (Dawkins, 1976). Otherwise, how much we care about each other is necessarily a matter of the prevailing social norms and pressures in the society in which we live (Sen's "cultural orientation" of society), and therefore open to social manipulation or conditioning. Relaxing Sen's assumption (i), we may introduce the so-called altruistic externality, so that, e.g. $U_i = g(\underline{x}_i, \underline{x}_j)$, with $g'_{x_j} > 0$ for some individual or group $j \neq i$, where $\underline{x}$ is a

consumption or payoff vector. Of course this does not capture altruism in the usual sense, that is, behaviour which increases the welfare of others at the expense of one's own. For assumptions (ii) and (iii) are still in force, and behaviour remains essentially selfish: the "charity of the uncharitable". To model pure altruism, we must again relax assumptions (ii) and/or (iii), and admit the possibility of (socially-prompted) behaviour that is independent of self-welfare. Either way, altruism in the PD situation converts the individual payoffs from alternative strategies to weighted averages of the two players' rewards. Cooperative behaviour will then prevail if the weight attached by player i to player j's payoff, v_{ij} (with $0 < v < 1$), is sufficiently high (Collard, 1978; Stark, (1987). But as Collard was first to show, the critical value of v_{ij} depends on the degree of "assurance" that j will also cooperate. Thus, for the payoffs given in table 1, which as it happens correspond to Collard's deviation-form payoff matrix, cooperation requires $v > 1/2(1 - \Pi/2)$, where Π is the subjective probability held by e.g. player i that player j will cooperate.[9/] If, for example, there is complete assurance ($\Pi = 1$), the required v is $\frac{1}{4}$, whereas if there is no assurance ($\Pi = 0$), it is $\frac{1}{2}$. Notice that to ensure the cooperative outcome, v must be both large enough and mutual (though not necesarily symmetric). Subject to this, however, we see that altruism alone can break the prisoners' dilemma, even in a one-shot game. However, on orthodox assumptions (in particular that (ii) and (iii) hold), and in the one-shot game where the benefits of continued cooperation over time are absent, assurance alone will not suffice. Even with complete assurance ($\Pi = 1$) we still require $v > \frac{1}{4}$; assurance facilitates cooperation where altruism is present, but is not itself sufficient.

Reciprocity

Axelrod (1984) identifies reciprocity as the fundamental requirement for the evolution of TIT FOR TAT cooperation as a collectively stable strategy (or in Dawkins' (1976) terminology, ESS) in iterated games. Axelrod explains that reciprocity involves being initially nice (not being the first to defect); quickly provocable (immediately retaliating to others' defections); and forgiving (returning immediately to cooperative behaviour after the opponent has done so). TIT FOR TAT satisfies these conditions, and is in addition clear (easy to recognise, and easy to see as the best strategy to reciprocate). Finally, TIT FOR TAT is self-policing, requiring no central authority. However, reciprocity works only in repeated games, where what Axelrod terms the "shadow of the future" (i.e. the discounted value of future stage payoffs) is large enough.[10/] Thus it is not effective in a one-shot game. For the cooperative process to get started there must be a sufficient cluster of individuals who cooperate at first and discriminate according to the opponents' response. But once established in a population, cooperation based on reciprocity is collectively stable in the sense that it can protect itself from invasion by uncooperative strategies both from within and from without; as Axelrod and Dawkins both show, deviant strategists will earn less than the average population score payoff, and tend to conform. Notice that reciprocity in some ways resembles assurance which, as we have seen, and consistently, is also not effective in the one-shot game by itself.

Axelrod points out that individuals do not have to be rational for a stable cooperative outcome based on reciprocity (the

evolutionary process allows successful strategies to survive even if the players do not know why or how). Nor is there a need for the players to communicate or enter into binding contracts (their deeds speak for themselves). Trust is also not a requirement (reciprocity itself makes defection unproductive). Furthermore even egoists will cooperate so that altruism is likewise not required (though a measure of "niceness" is necessary to ensure a sufficient cluster of initial cooperators for cooperation to get started). Finally, since cooperation based on reciprocity is self-policing, there is no need for central authority. The (minimal), essential requirement is recognition of other players, and recall of their strategies. The durability of social interactions betwen given individuals is important both in this regard and also to help ensure that the "shadow of the future" is large enough (by increasing the probability of players re-encountering each other). Social practices and institutions (including business organisations), which help increase recognition capabilities, the frequency of social encounters, and the durability of social relationships, can therefore contribute to the evolution of cooperation, and this is important for our analysis of work-organisation and profit-sharing in the next section.

Golden Rule

At first sight, treating others as one would be treated by them appears to combine elements of altruism, assurance and reciprocity. But while caring for others may be accepted as part of the underlying, absorbed value-structure of those who practice it, assurance is irrelevant (because GR behaviour is undertaken regardless of what others do) and reciprocity is neither complete (defections are

not punished) nor the governing behavioural principle. However this may be, GR behaviour does occur. For example most people do not steal, even when the probability of detection is zero; some pick up litter in the street whether others do or not. Such behaviour is perhaps best understood not in utility terms (assumptions (i) - (iii) are all in abeyance), but as the ultimate degree of social conditioning, where social norms and values have been fully internalised. Where it exists, GR behaviour offers a direct escape in the one-shot PD game; it is easy to see that if there is a social norm of always cooperating, this will secure the Pareto-preferred outcome. But unlike reciprocity, GR is not self-policing, and for that reason not ESS in iterated games. In Axelrod's terms, GR is too "nice", and hence vulnerable to invasion from within or without by deviants who go unpunished. To avoid this would require either a central authority supplying retribution, or a social "super-ego" sufficiently effective to constrain deviant strategists. However, in a population playing TIT FOR TAT, GR behaviour does equally well. In fact until someone (e.g. a newcomer) defects, the two are observationally indistinguishable. Hence, as in Dawkins' hawk-dove scenario, there is a plausible polymorphic result featuring a majority playing either consistent TIT FOR TAT or TIT FOR TAT with occasional "probing" defections, in association with a small GR minority that oscillates mildly in size (Dawkins, 1976, p 80).

IV. PROFIT-SHARING, PARTICIPATION AND CO-OPS IN A PD CONTEXT

Under the joint hypothesis that a control/technology tradeoff operates, and that profit-sharing and/or participation etc. can be effective in securing a cooperative outcome, we would expect to

observe systematic differences in the nature of technology between firms utilising "traditional" and "alternative" methods of work organisation. This suggests that it is important when testing for the productivity or other performance effects of organisational choice to allow for potential interactions between e.g. profit-sharing and technology, input qualities and so forth, whereas most previous work has, at best, merely normalised for these factors.[11/] Tests for the significance of the relevant interactions may then be interpreted as tests of the joint hypothesis.

Profit-sharing, per se, appears more capable of playing a relatively minor, contributory role in securing cooperation, than in securing it outright. Viewed in the context of a PD game, the effect of profit-sharing can be seen as modifying the stage payoffs, and thereby introducing a quasi-altruistic externality on the part of workers; under a sharing system the illustrative utility vectors on p5 become $\underline{Y} = (\pi)$ and $Z = (w, L, \pi)$. In this sense, profit-sharing could foster what the Green Paper mooting tax-incentives for profit-related pay in the UK termed "employee identification" and "employees' commitment to the success of their company" (HMSO, 1986, p3), if "success" means profit, as in the Green Paper it probably does. But as we have seen, altruism resolves the prisoners' dilemma only when present above a certain critical level, depending on the underlying payoff-structure and the degree of assurance in particular cases. The level of profit-sharing which would be necessary to satisfy this condition, in general or in typical circumstances, is strictly unknown, but we note that the degree of profit-sharing contemplated by the Green Paper is relatively modest, and that previously chosen by profit-sharing firms more so.[12/] Moreover, altruism must also be

mutual if it is to break the PD problem, and profit-sharing offers no explicit quid pro quo on the part of employers; there is nothing which patently and collaterally increases the firm's commitment to its workers.[13/] Finally, as we have seen, it is not altruism but reciprocity which offers the best chance of resolving the prisoners' dilemma in repeated games. It is here that the alternative, contributory role of profit-sharing emerges. Axelrod (1984, p135) points out the usefulness of altruism (whether genuine or, as in this case, bogus) in helping to establish reciprocity; in particular, caring about each other (even to the limited extent of sharing a common goal) can encourage "niceness" and thus help provide the initial cooperation which is necessary to get reciprocity started.

Contrary to received wisdom, our analysis suggests that the trust-building/contract-facilitating properties of participation may have been over-emphasized in previous discussion. As we have seen, trust is not a requirement for cooperation based on reciprocity; what matters are recognition, recall and the durability of relationships (coupled with the freedom of action to punish defections). Trust-building would be more important if fostering assurance with respect to rival's behaviour - which, as we have seen, interacts with altruism - were the prime consideration. But since it is reciprocity, not assurance/altruism which provides the main escape route from the prisoners' dilemma in repeated games, considerations other than trust-building loom larger, including the ability of both sides to punish defections.

Our conclusions in this respect diverge sharply from those of some previous writers, including Grout (1984). He analyses a two-

stage game in which the firm precommits investment, but unions (workers) cannot commit the level of labour supply for a given wage. Their inability to do so derives from their legal immunity in trade disputes. Grout's finding, consistent with those from previous analyses of sub-optimisation games of this type (McCain, 1982), is that investment will be suboptimal if the union has any power. The present analysis, by contrast, recognising the repeated PD character of strategic interaction between workers and employers within the firm, not only relegates the question of players' ability to enter into binding commitments, but also underlines the positive aspects of union power. In particular, it emphasizes the desirability of union freedom to punish employers' non-cooperation (which their legal immunity enlarges), as a necessary condition for the evolution of reciprocity-based cooperation.

However, other features of participatory work-organisation clearly could facilitate reciprocity-based cooperation. When, for example, a firm voluntarily introduces say, a joint decision-making "scheme", it transmits a clear signal of intent to cooperate, thus facilitating recognition of the strategy it wishes to pursue. The signal will be especially powerful if the scheme involves the irreversible release of strategic information, and so forecloses or circumscribes later reversion to non-cooperative behaviour. No such signal will, of course, be given in the case of non-voluntary, legally-imposed co-determination schemes. Secondly, participatory schemes involving joint decision-making and access to information will tend to erode the status hierarchies, and blur the "labels" (in this case attached to "workers" and "employers") which, as Axelrod (1984, ch.8) shows in a more general context, can inhibit the emergence of

TIT FOR TAT. This effect will be enhanced if ancillary provisions of the participatory regime minimise distinctions between workers and employers with respect to such matters as eating, washroom and car-parking facilities, modes of payment and address, etc. Thirdly, participatory decision-making directly increases the frequency of interaction between workers and employers, thereby creating a greater, and more varied, number of opportunities to confirm the other side's continued cooperation and or to retaliate against its defection. The effect here is somewhat akin to the benefits Axelrod (1984, p.132) identifies in breaking down arms-race negotiations into a series of small agreements. Finally, participation can increase the durability of the two sides' relationship, and so enlarge the "shadow of the future" (the importance of which in maintaining TIT FOR TAT Axelrod repeatedly emphasizes), to the extent that, as argued elsewhere, technological and factor-input choices associated with participation tend towards human-capital enhancement and longer expected employment durations, as opposed to traditional, "Taylorist" policies of deskilling and high labour turnover (Cable, 1987).

The extreme participatory form of the producer co-operative (PC) at first sight seems to offer an immediate escape from the underlying PD problem; there are no longer two distinct sides (players), so strategic control is not an issue, and maximisation of the joint welfare function $J = J(\underline{Y}, \underline{Z})$ will apparently lead to an equilibrium on the unconstrained frontier at a point determined by the relative weights attached to $\underline{Y}$ and $\underline{Z}$ in the cooperative's utility function (Ben-Ner and Estrin, 1985). However, PCs could face other kinds of technological constraint (arising, for example, from the implications of certain technologies for interpersonal relationships

within the enterprise which are incompatible with cooperative principles). Thus the advantages of PCs over traditional firms (or vice versa) with respect to access to "best practice" technology are not clearcut. Moreover, the conflict between cooperators' interests qua workers and qua owners has merely been internalised, and remains to be resolved; breaking down the divisions between labour and capital via large ownership shares for workers (Oakeshott, 1978; Horvat, 1982a,b.) changes the strategic structure of the game, but does not remove the fundamental, underlying choices. Our PD approach also highlights new considerations with respect to the problems which cooperatives are commonly though likely to encounter over intrafirm hierarchical structures; again these concern the frequency and durability of interactions between individuals within organisations. Axelrod points out the efficiency of traditional hierarchial organisation in concentrating interactions between specific individuals. Thus, specialisation leads to people who are working on related tasks being grouped together, while inter-departmental matters are referred to a higher level, where the frequency of meetings is greater amongst departmental heads. The result is that, "by binding people together in a long-term, multilevel game, organisations increase the number and importance of future interactions, and thereby promote the emergence of cooperation among groups too large to interact individually. This in turn leads to the evolution of organisations for the handling of larger and more complex issues", (1984, p.131). The PD approach thus reveals that it is these benefits which are lost to cooperatives who avoid traditional hierarchical structures (on the grounds that the division of labour and superior/subordinate relations they entail are inimical to cooperative principles). On the other hand, cooperatives may be expected to

self-select cooperators, and this is an offsetting factor.

Finally, the PD approach offers a ready interpretation of recent anti-participatory, Thatcherite policies, and a comment on their long-term viability. The policy set in question includes, on the one hand, rhetorical and other emphasis on the "right of management to manage", the virtue of "wealth-creation" and the legitimacy of its rewards, and the appropriateness and social acceptability of greater income-inequality; on the other hand, we have also seen a series of measures to curb trade union power and activity (strike ballots, restrictions on picketing, removel of legal immunities, unemployment, and so forth). Taken together, and seen in a PD context, these measures appear calculated to eliminate the possibility of the conflict outcome I in figure 1 (by removing or drastically curtailing workers' ability to take unilateral action, i.e. emptying the workers' action set $\underset{\sim}{A}_w$) while at the same time legitimising the (employers') temptation payoff E^* (modifying the payoff value to employers by the removal of social inhibitions which might otherwise be present concerning the exercise of authority and the taking of rewards).[14/] The comment on the long-term viability of the strategy is that this is not a natural, consensus equilibrium, and may be expected to require continuing policy enforcement; and the removal of workers' sanctions is inimical to the eventual restoration of cooperation, insofar as the ability to punish defections is, as we have seen, essential for the establishment of TIT FOR TAT.

V. CONCLUSIONS

Where the choice of technology affects intra-firm bargaining

power and control over production, strategic interaction between workers and employers in the firm can take the form of a repeated PD game. Previous work indicates four potential escapes from the prisoners' dilemma: socially modified payoffs; altruism/assurance; reciprocity-based cooperation (TIT FOR TAT); and 'golden rule' behaviour. Reciprocity appears the most effective of these in repeated games. Against this background, our analysis suggests that less importance than hitherto be given to the role of profit-sharing as a means of increasing workers' sense of identity with the firm, and to participatory work-practices as a means of increasing mutual trust and the making of binding contracts. However profit-sharing could help get reciprocity-based cooperation started, and the effects of participation on the form, frequency and durability of worker-employer relationships are likewise revealed as conducive to its evolution. The absence of traditional hierarchial structures in producer cooperatives operates against the emergence of reciprocity for other reasons, though special considerations apply in this case. Recent governmental policies in the UK favouring the reassertion of employer control are seen as leading to an unstable equilibrium, requiring continuous policy intervention to maintain.

FOOTNOTES

1. Babbage (1832, p.19) 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", and Ure (1835, reprinted 1963 p.54): "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". For a more recent, illustrated account of technological control, see Edwards (1979, ch.7).

2. Aoki (p.600) traces the concept of organisational rent to Marshall. Associated ideas are to be found in the internal labour markets literature (e.g. Doeringer and Piore, 1971; Williamson, Wachter and Harris, 1975).

3. For an engineer's view on the misuse of human capabilities, see Rosenbrock, 1983.

4. Further examples may be found in the application of computer-controlled production systems (Melman, 1983) and, arguably, in the current UK government's preference for road over rail transport, and in its insistence on the retention of a nuclear element in privatised electricity generation (contrary to commercial judgement).

5. The existence of an interior optimum implies that beyond some point the distributional gains from increased control no longer

exceed the accompanying productivity losses. In the absence of an interior optimum, E^* will be at a corner solution with workers' payoff driven down to the constraint level $\bar{G}$. The underlying PD structure is unaffected.

6. The PD payoff ordering requires

$$T > R > P > S \quad , \text{ with } \quad R > (T+S)/2$$

where R and P are the (mutual) rewards for cooperation and penalty for non-cooperation respectively; T is the (illusory) 'temptation' payoff when e.g. player i defects and j cooperates ($i \neq j = 1, 2$); and S is the 'sucker' payoff to j in this case (Axelrod, 1984, appx B).

7. The logic is similar to that in Selten's chain-store game. By contrast, in an infinite game "any average payoff vector in the intersection of the positive orthant and the convex hull of the four possible stage payoff vectors can be achieved through a perfect equilibrium" (Kreps, Milgrom, Roberts and Wilson, 1982).

8. In one-shot public goods experiments, the public good was typically provided at 40-60% of the optimal quantity (except when the subjects were economics graduate students, when the level of provision was 20%).

9. As Collard shows, the return from cooperation exceeds that from (what we call) control when

$$(1 - v)\pi + v\pi - 2(1 - v)(1 - \pi) + 2v(1 - \pi) > 2(1 - v)\pi - 2v\pi \quad ,$$

which simplifies to the condition given in the text.

10. See Axelrod's proposition 3 (1984, Appendix B, pp.210-211).

11. In this context c.f. FitzRoy and Kraft (1986, 1987) and Cable and Wilson (1988a, 1988b).

12. The Green Paper proposed tax relief on performance related pay up to 20% of total earnings. The proportion of earnings accounted for by profit-sharing in a sample of West German engineering firms was 7.3% (Cable, 1988) and in a comparable sample of UK firms, 2.4% (Cable and Wilson, 1988c).

13. Unless Weitzman's (1983, 1984, 1985) conclusion that profit-sharing results in permanent excess demand for labour is both true and generally accepted and, furthermore, generally perceived by workers to constitute an effective guarantee of employment.

14. The policy cannot alternatively be viewed as attempting to effect a move from W^* to N in figure 1, since the rhetoric would in that case emphasize not the "right to manage" but the need for cooperation.

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TABLE 1 : ILLUSTRATIVE PAYOFF MATRIX

		Co-op	Control
WORKERS	Co-op	6, 6 (N)	3, 7 (E^*)
	Control	7, 3 (W^*)	5, 5 (I)

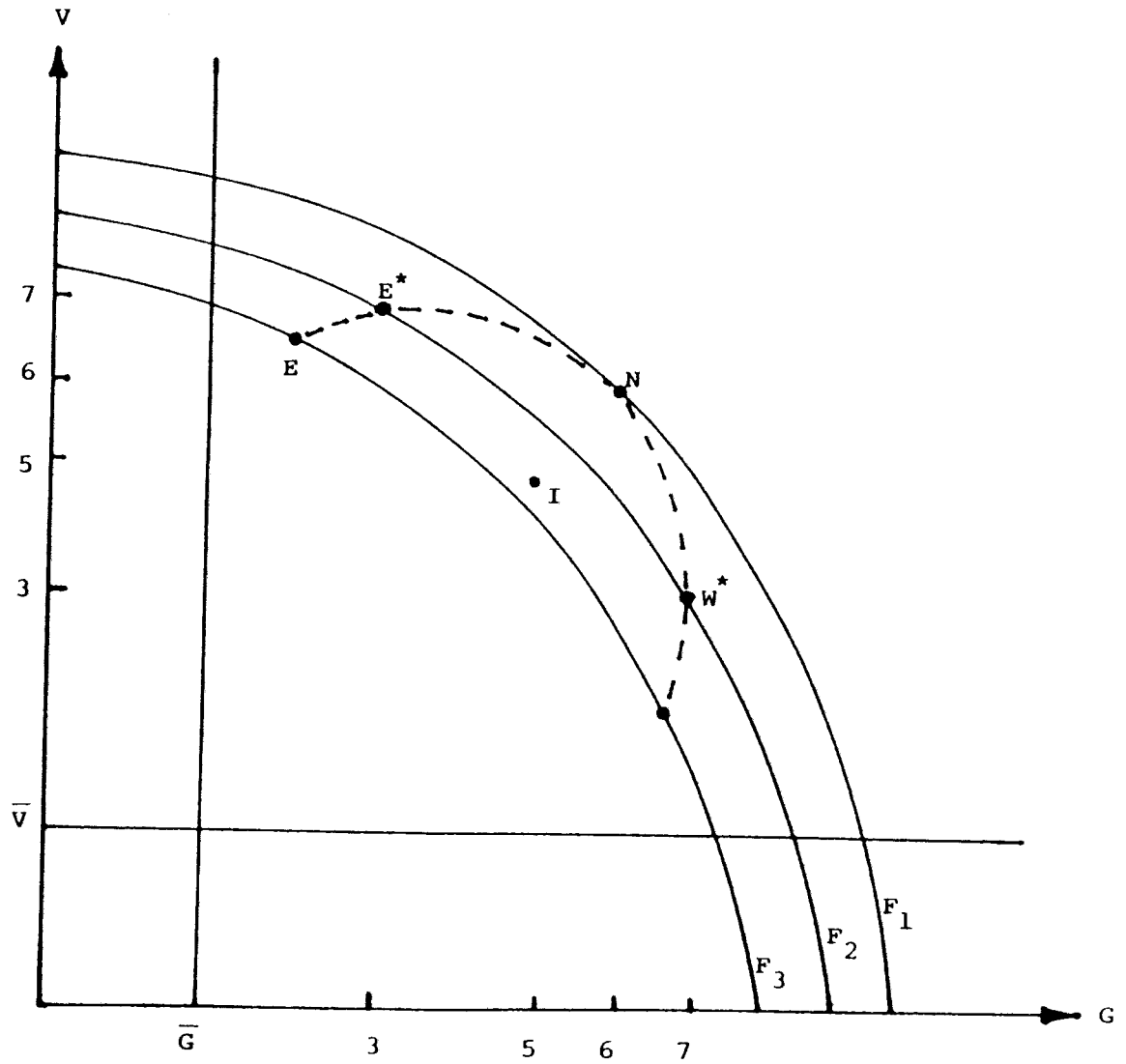

FIGURE 1