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SOCIAL INSTITUTIONS AND TECHNICAL CHANGE

by

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When David M. Gordon introduced the term "social structure of accumulation" in the late 1970s he pointedly focused the attention of economists and historians on the social nature of long term economic fluctuations.[1] As he and his later co-authors put it, we may mark the passage from one distinct period of capitalist growth to another more insightfully by the bunching of institutional innovations then by the bunching of technological innovations. Those who have followed Gordon (including the present writer) have thus shown more interest in the emergence of collective bargaining and the growth of the welfare state than in the development of the automobile, plastics and the computer.

But surely our lack of attention to technology is misplaced, the consequence not of any considered conviction of its secondary nature but rather simply of the impossibily demanding nature of the research agenda opened up by Gordon (and, one might add, by his counterparts in the French "regulation" school). How, then, might the social structure of accumulation school take more adequate account of technology?[2]

The structure of the social structure of accumulation argument, at its simplist, is that the rate of accumulation is propelled in large part by the rate of return on capital, which is in turn strongly influenced by institutional relationships which make up the social structrue of accumulation.[3] The rate of

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1. David Gordon (1980). What has come to be termed the "regulation" school developed a distinct but related analysis. See Robert Boyer and Jacques Mistral (1978), Alain Lipietz (1979) and Michel Aglietta (1979) and later works surveyed in Boyer (1986).

2. My thinking on these issues has benefited immeasurably from conversations with Simon Avenell and Steven Cohn. I would also like to thank Barbara Goldoftas for assistance in preparing this paper, and the University of Massachusetts Faculty Fellowship and the Ford Visiting Professorship at the University of California at Berkeley for financial support.

3. A historical account of the post World War II U.S. economy along these lines is developed in Samuel Bowles, David Gordon, and Thomas Weisskopf (1983). The relationship of the rate of accumulation to the rate of return on capital is explored econometrically in a social structure of accumulation framework in Bowles, Gordon, and Weisskopf, (1988).

return on capital is understood primarily as a measure of the power of the capitalist class -- both singly and collectively -- in its interactions with other economic agents: the working class, the state, and external buyers and sellers.[4] For technological considerations to play a significant part in this account they must shed light either the power of capital directly or the institutions which make up the social structure of accumulation.[5] Thus the complex relationship among technology and social institutions becomes central to the study of long term economic growth.

Among economists, surprisingly, technology and social institutions are generally taken as circling in different orbits; the former following its teleological course of more or less rapid improvement and the latter consigned to live out their sedentary lives of historical inertia until displaced by some cataclysmic event or movement. A more integrated conception of technology and social institutions will require rethinking and amending a basic economic concept: exchange.

Capitalist Technology and Contested Exchange

If the expression "capitalist technology" startles the reader as an inappropriate juxtapositon of terms, much as did Marx's ironic "yellow logarithm," it may be due to the imposing influence of the now-dominant neoclassical economic paradigm. For it is not difficult to show that given the usual assumptions of the neoclassical model, technical choice will follow the dictates of a microeconomic logic which may be described as institution-free: in seeking the least-cost set of production inputs from the available methods of production, owners of firms (or their delegated representatives) will never select a method of production which is technically irrational in the sense that (by comparision to some other available method of production) it uses more of at least one input and not less of any input to produce a unit of output. Robert Dorfman speaks for an entire school of thought in commenting on the manager's choice of technique: "This search results, of course, in efficient operation of

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4. This understanding of the profit rate is developed theoretically and illustrated econometrically in Gordon, Weisskopf and Bowles (1986).

5. These are the connections to which the social structure of accumulation framework points most unambiguously; others may be imagined. The focus on power and social relations favored by the social structure of accumulation approach to the profit rate may be contrasted with the emphasis on the relationship between technical progress and organic compositon of capital characteristic of classical Marxism.

their plants."[6]

Technical evolution may still reflect the nature of social institutions, even in a perfectly competitive world, but the effects of social institutions operate exclusively via phenomena exogenous to the firm: the preferences of economic agents, the availabliity of applied scientific knowledge and the distribution of factor ownership amongst economic agents.[7] Given these conditions external to the firm, the choice of technology is independent of relations of ownership either within the firm or between it and other economic agents: Paul Samuelson aptly remarks that "in a perfectly competitive model it really doesn't matter who hires whom: so let labor hire 'capital'."[8]

There is distressingly little that one can say about the relationship between institutions and technology in this framework, for it exhibits in pure form the disjuncture between production and institutions which has been favored among economists since Leon Walras. Methods of production may be characterized by their factor intensity, economies of scale, degree of substitutability among inputs and level of output per unit of input, but none of these bear any direct relationship to the structure of social institutions beyond the claim that technically dominated processes will be eliminated through the process of cost minimizing technical choice outlined above.[9]

The methods by which we produce our goods and serivces are thus subject to technical but not social evaluation. David Noble writes:[10]

> Thus, when we see a technology in regular and widespread industrial use, we confidently assume that it represents the best history has to offer, since it survivied the successive tests of this process of natural selection. And in this way we routinely dignify the present array of technology as the highest expression to date of so-called technological progress and, as such, we accept it as inevitable, a

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6. Dorfman (1967), p. 51.

7. A variant of neoclassical economic history would take the case futher and argue that in the long run the nature of property rights and other institutional arrangments will develop so as to make optimal use of evolving technolgoical opportunities. This may be recognized as a kind of gradualist version of Marx's conviction that the long run dominance of the forces of production over the social relations of production would be secured through revolutionary institutional innovation when existing arrangements become outmoded.

8. Samuelson (1957), p. 894.

9. Murray Brown develops this four fold representation of technologies based on the parameters of the production function in his now standard neoclassical work (1966).

10. Noble (n.d.) p. 4.

fact of life...

The critque of technology is reduced to a lament against nature itself, or to a concern about the pace of technological change.[11]

If we are to make sense of the expression "capitalist technology" and to understand the critical connotations which appear to accompany it, we must move to an entirely different conceptual terrain, one in which the exercise of power plays a more integral role in production. This is the framework initiated by Karl Marx and extended in quite different ways by Amit Bhaduri, Stephen Marglin, and Harry Braverman in the early 1970s.[12] "It would be possible," Marx told the readers of Capital, "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."[13]

The common theme in what may be termed this non-Walrasian approach is the centrality institutional arrangements to an understanding the process of technical evolution. Its essential contribution is to represent economic interactions not only as voluntary exchanges but also as relationships of domination and subordination, the enforcement of which may be furthered by the choice of technique.

To the extent that employers collectively determine the choice of technique or the range of available techniques, the exercise of class interest in technical evolution might be anticipated. This possibility would be conceded by economists of all description and is readily accomodated within the neoclassical framework.[14] What is at issue is the the claim that non-colluding profit maximizing capitalists will generally select technologies which are in a well defined sense inefficient, that the resulting inefficiencies are empirically significant enough to warrant our attention, and that there exist feasible alternative institutions which might not entail this form of economic irrationality. For the term "capitalist technology" to be both conceptually coherent and interesting all three claims must be sustained.

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11. It hardly need be added that even within the neoclassical framework the rate of technical progress cannot be precisely defined except under the most implausible assumptions.

12. Bhaduri (1973), Braverman (1974) and Marglin (1974). The subsequent contributions have been too extensive to cite.

13. Marx (1967), p. 436. William Lazonick (1979) provides a not entirely favorable historical assessment of Marx's claim, with reference to the self-acting mule.

14. See for example Samuel Bowles, Peter Dixon and David Kendrick, (1971).

In order to address the first of these claims (I will only touch on the remaining two) I will develop a very simple general model of production and exchange quite divergent from the Walrasian view, using illustrative examples from three distinct epochs of capitalist development.

It may be insightful to begin the development of the alternative model by inquiring what it is about the neoclassical model which renders it so unaccomodating to institutional concerns. Abba Lerner identifies what I will argue is the key committment of the neoclassical approach when he writes, "An economic transaction is a solved political problem."[15] He goes on to note that in economics (meaning neoclassical economics) a conflict takes the form of a contract. As we shall see, the logic of the neoclassical model requires that the claims arising from these contracts be enforceable at zero cost to the exchanging parties; contract enforcement is secured through state action at insignificant cost to the agrieved party. This is what makes neoclassical exchange a "solved political problem."

The microeconomic logic of the non-Walrasian approach may be captured in a model in which exchanges on both product and input markets as well as credit markets give rise to claims which are not costlessly enforced by the state but which are enforceable in varying degrees through strategies adopted by the exchanging parties. Herbert Gintis and I (1988) refer to these non-Walrasian transactions with endogenously enforced claims as contested exchanges.

Strategies of enforcement are generally costly, involving the use of personel and equipment to collect informantion and induce compliance. Technologies are developed and selected by firms with the problem of claim enforcemnt in mind. Thus technologies are not only means of transforming outputs into inputs, they are also integral parts of strategies of enforcing conflicting claims and organizing social relationships. As we shall see, an important result follows: inefficient technologies which facilitate claim enforcement may be prefered to efficient technologies which exascerbate the enforcement problem.

The inadequacy of the neoclassical account of technical change is attributable to the fact that the major markets affecting innovation and technical choice -- labor markets, credit markets, and markets in information-related products -- all give rise to contested exchange, and for this reason technical choice and the direction of innovative activity will reflect the capitalist's desire to minimize enforcement costs as well as production costs.[16]

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15. Lerner (1972), p.259.

16. On credit markets, labor markets and information related markets

In the pages which follow I will consider the relationship between enforcement costs and technical choice with respect to both the employment of labor and the marketing of the product. I will first illustrate the microeconmic logic of what are called deskilling technologies by reference to technical change in the food processing industry in the late 19th century. I will then consider what I term labor monitoring technologies introduced in the 20th century. Lastly I will introduce commodity rights enforcing technologies as illustrated by the case of genetic research. In each case I will focus on at least one specific example with the intention of lending a bit more concreteness to a field of study which has perhaps been lacking in this respect.

Labor Homogenizing Technologies:
Cox's Capper vs. Craft Labor in the 19th Food Processing Industry

As is now widely recognized, labor markets are a prototype case of contested exchange. Because the amount and quality of work done per hour is to a major extent determined -- at least in an immediate sense -- by the worker, and because employers and workers interests generally are not identical in this matter, the employer must develop what may be termed labor extraction strategies to ensure that a sufficient amount of work is done to render production profitable, given the other parameters facing the firm. The choice of technology, as we will see, may be an instrument in this strategy.

Let us consider the case of the food processing industry in the late 19th century, an industry whose labor relations have been carefully studied in a series of papers by Martin Brown and Peter Philips:[17]

> The cannery owner of the 1860 to 1880 period faced ... basic constraints which limited his control over productive inputs. ... After the raw produce had been worked-up and put into cans ... the cappers, who were specialized tinsmiths, sealed the cans. ... The bargaining power of the cappers ...was rooted in their strategic location in the production process ... (which) ... would not have been crucial if they could have been quickly and easily replaced in the event of a strike or strike threat; but that was not the case. Cappers had fairly complex tinsmithing skills and the training system for acquiring these skills was not controlled by the canner owners. (130-131)

The replacability of the worker was clearly a key element in any successful strategy for controlling the cappers' labor:

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respectively, see Herbert Gintis (1986), Bowles (1985), and Arrow (1962).

17. See, especially, Brown and Philips (1986) upon which this account is based. All quotations are from their paper, including that from Cox, whom they cite.

> In order to deter...strikes and to render the capper a bit more manageable and diligent employee, the cannery owner needed to make the capper's replacement a plausible consequence of worker recalcitrance.(134)

Both owners and inventors sensed that mechanical innovation might undermine the cappers' position. Newly developed hand-powered capping machines were installed in some canneries, not for general use, but to hold in reserve in the event of a strike.

But it was James Cox's invention of the mechanical capper that turned the tables against the cappers. The device was not the result of idle technological curiosity; Cox had a sensitive understanding of the cannery owners' predicament. Writing 26 years after the initial introduction of his machine, he recalled:

> In those days the capping all having to be done by hand, a Boss Capper took the contract to do the work, furnishing his men for the purpose, and even the owner stood in great awe of him, for of what use was it to purchase tomatoes and prepare them if, at the important moment, the Capper decided he would go on strike; or having received his pay, required more time to sober up than the boss thought necessary. ... It was this helplessness of the canner that made him a willing advocate of every mechanical means and made possible the working out, through frequent failures and heavy losses, the perfected mechanical means now in use. (134)

Brown and Philips confirm what might be inferred from Cox's last sentence; the introduction of Cox's Capper, as it was called, did not initially raise the productivity of the capper at all. But it was widely adopted nonethless because, in the words of a contemporary observer, "it relieved the employing packers of the domination of the boss capper." (136)

We may capture an essential aspect of this historical episode in the following way. Prior to the introduction of the new technology, the cappers, whom we will represent as the only type of labor involved, received what may be termed a considerable employment rent: their wages exceeded those of their next best alternative, w'.[18] Assume that new workers may be recruited by the firm at the wage w' but in order to do capping work each new worker must be acquired at a recruiting cost of c_t.[19] Then the cappers union will be able to strike

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18. I assume that their alternative to work as a capper was the certainty of finding a job at w'; nothing critical is lost by abstracting from the possibility of not finding a job at all and of receiving income from non-labor market sources such as family or the state. For analogous reasons I confine the model to a single time period.

19. It is immaterial to the firm whether this is a "training cost" related to the ability to do capping tasks in any substantive way or instead represents a "toll", unrelated to concrete job performance, which cappers have managed to

successfully for any wage less than w' plus c_t, assuming that this wage is not so high as to prompt the firm to cease producing altogether. Correspondingly the firm, which wants to avert a strike, will have to offer what may be termed the strike averting wage, w' plus c_t.

If the effect of the introduction of the new technology is to reduce c_t and to leave the level of output per worker hour and other relevant data unaltered, it will clearly be profitable for the firm to adopt the new technique.[20] Equally clearly, the new technology will enhance the firm's profits even if it has the effect of lowering the productivity of labor, as long as the reduction in recruiting costs is sufficiently great.

This form of technical change represents a process which Harry Braverman called deskilling -- the erosion of the power of craft labor through the development of technical and organizational methods of production which undercut the workers' monopoly of a particular skill. This may be a rather prevalent form of techical change: Marx initiated the literature on this subject with his discussion of the self-acting mule; Katherine Stone (1974) documents this process in the late 19th century U.S. steel industry, and it is a dominant influence on labor relations in the printing industry in the mid to late 20th century.

Braverman's much used term, however, may be somewhat misleading, for the workers who replace the craft workers (or threaten to do so) need not be less skilled in any of the possible senses of the word; what is crucial is that they be sufficiently abundant, unorganized, or deprived of other employment opportunities to command a lower employment rent than the craft workers. The key contribution of these technologies to profitability is to make labor more easily replaceable, which is to say, replaceable at less cost. Because this may generally be done by eliminating unique characteristics of a particualr type of concrete labor I will refer to these technolgies as homogenizing rather than deskilling.

The radical equalization of the wage structure in the California canneries between 1870 and 1910 reported by Brown and Philips may reflect at least in part the effects of homogenizing technologies. Over this period the male wage structure shifted from a high variance bimodal distribution to a unimodal distribution with very little variance; the ratio of women's wages to mens wages rose from .42 to .86.

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extract from employers.

20. Though I will not pause to develop this line of reasoning at each point in the pages which follow, it is also true that under quite general conditions, the industry-wide adoption of the new technology will also raise the common competitive profit rate in the economy as a whole.

This simplified discussion of the case of Cox's Capper hardly does justice to the historical record; nor does it address the more general issues of the relationship between firms' labor extraction strategies and technolgy. I have represented the workers' options as simply to work or to strike and have thus abstracted from the firm's more general problem of the control over the pace of work. To this more general problem we now turn.

Technological Monitoring of the Labor Process

A more complete model of the production and labor extraction process will illuminate our next example -- monitoring technologies -- and will allow a restatement of the logic of homogenizing technologies.[21] The dual overriding concerns of labor control systems -- homongenization and monitoring -- was aptly captured by the German industrialist Alfred Krupp:[22]

> What I shall attempt to bring about is that nothing of importance shall be dependent upon the life or existence of any particular person; that nothing of importance shall happen without the foreknowledge and approval of management.

The connection between Krupps objectives and technology may be clarified by a simple model.

Consider a particular firm whose output over some period of time, Q, is simply the product of the number of labor hours hired h, the amount of work done per hour e, and the amount of output produced per unit of work done, q or

(1) $Q = heq$

The level of output per unit of work done, q, depends on a vector of material inputs, x, or

(2) $q = q(x)$

Because x represents a vector of material inputs in the production process -- so many kilowatts of electricity, so many hours of work by machine of type n, and the like -- it also represents an aspect of the technology in use. But as we will see, equations (1) and (2) -- the firm's production function -- do not adequately capture the determinants of technical choice.

The amount of work done per hour will be influenced by the formal or informal work rules which are in force, the extent and degree of observation of safety

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21. The model of labor extraction is presented more fully in Bowles (1985).

22. Quoted in Daniel Yankelovich and John Immerwahr (1984), p.58.

regulations, the amount of contrived or unavoidable machine down time, and the like. We will summarize all of these and other influences on the amount of work done per hour in a labor extraction function expressing the workers response to the labor control strategy devised by their employer. For simplicity we assume that workers are identical in the sense that their productive capacities and their work proclivities (their responses to various extraction strategies) are the same. The amount of work done per hour is determined by workers as a whole on the basis of their collectively held notions of what is a fair and reasonable amount of work for the employer to expect as well as the workers' perceptions of the likely consequences of violating the employer's desired level of work effort, e^c.

Given workers' conceptions of what was once termed a "fair days work" -- that at which they would work by choice, e^w, and assuming that their employer would like them to work harder than this ($e^c > e^w$), the level of work will respond to the expected cost of violating the employers expectations, c^

(3) $e = e(c\hat{})$ where for $c\hat{} > 0$, $e' > 0$, and $e'' < 0$; and $f(0) = e^c$

The expected cost of violating the employer's work expectations is the product of three terms: the expected probability of being detected if not working up to standard, d^, the expected probability of having one's job terminated if detected not working up to standard, t^, and the expected cost to the worker of losing his or her job, w^c, or

(4) $c\hat{} = d\hat{}t\hat{}w^c$

The employers extraction strategy may be expressed in terms of the three components of the righthand side of this expression.

The expected cost of job loss, w^c, is the worker's employment rent or the difference between the wage -- which is an instrument in the employer's extraction strategy --and his or her next best alternative, which is exogenous to the firm.[23] We need only note that a viable labor extraction strategy entails a positive employment rent. Of more interest here are the probability of detection, d^, and the probability of job termination, t^.

Because $f' > 0$ and assuming w^c and t^ both positive, it will generally be in

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23. The value of the next best alternative will generally depend on expected duration of the spell of unemployment following a job termination, the level of the reemployment wage relatve to the current wage, the availability of labor income replaceing govenrment payments and the like, but its details need not detain us here for it plays no important part in the analysis to follow. See Juliet Schor and Samuel Bowles (1987).

the interest of the employer to deploy some system of surveillance to monitor the level of work being done. This will generally involve the employment of surveillance personel (supervisors) as well as the use of surveillance equipment (video cameras and the like). Where these surveillance inputs are not arguments of $q(x)$ -- and thus have not effect on production directly -- we term them pure surveillance inputs and denote their use per hour of labor employed as v. The methods of production in use, represented by the vector x, will also influence the probabilty that less than standard work will be detected, however, for the extent to which the contribution of each worker or groups of workers is readily monitored will depend on the layout of production, the equipment in use and the nature of the materials being processed. Thus the probability that substandard work effort will be detected is:

(5) $\hat{d} = \hat{d}(x, v)$

The probability of the worker being terminated if detected violating managements work norms, $\hat{t}$, will depend, among other things, on the cost of replacing the worker, which as we have seen will generally depend on the technology in use.[24] Thus

(6) $\hat{t} = \hat{t}(x)$,

and the labor extraction function may be written:

(7) $e = e(\hat{d}(x, v)\hat{t}(x)w^{c})$

The firm's production process -- its production function and labor extraction functon -- may thus be epxressed:

(1a) $Q = he(\hat{d}(x, v)\hat{t}(x)w^{c})q(x)$

Its choice of technique is dictated by the objective of maximizing

(8) $R = Q - wh - px.$

A change in technology, represented as a change in the vector x with w^{c} and v constant, will generally alter all three of the potentially effected variables, q, $\hat{d}$ and $\hat{t}$.[25] However, we may distinguish what may be termed pure cases: a

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24. The probability of termination will also depend on the level of demand for the firm's product, the seniority and other job security provisions in force, the expected effect of the termination on other employees' work levels or on the costs of recruiting additional workers, and the like.

25. We might also wish to consider the introduction of new pure surveillance processes or inputs; a <u>pure surveillance technology</u> might be defined as one which

pure efficient technology raises q without altering d^ and t^; a pure monitoring technology raises d^ without altering q or t^; and a pure homogenizing technology raises t^ leaving the remaining parameters unaffected.[26] By extension we may define an inefficient technology as one which lowers e. Profitable technologies -- those which reduce unit costs for a single firm adopting the technology -- may be simultaneously efficient, monitoring, and homogenizing, of course, although not in the "pure" sense defined above.[27]

The reader will note immediately that a profitable technology need not be efficient, for unit costs may be lowered by an inefficient technology which is either monitoring or homognizing. Figure 1 illustrates a simple case of inefficient profitable technical choice. The point x_o represents the levels of q and e associated with the technology in use and the optimal levels of v and w^c. Points a and b are alternative new technologies: output per unit of effort using technology a exceeds output per unit of effort using the current technology, which in turn exceeds b. In this sense we may say that technology a is more efficient than the exiting technology which is more efficient than b.

Let these alternative technologies be arbitrarily defined to have input costs identical to the existing technology and identical optimal levels of v and w^c.[28] The cost of an hour of labor using all three technologies is thus identical. The minimum cost of a unit of output will be achieved by maximizing the output per hour of labor, qe. In Figure 1 this clearly entails the choice of b, a technology which is inefficient with respect to both the existing technology and the alternative technolgy, a.

If the new technolgies can be combined, the cost minimizing choice will lie at a point along the locus of equally costly composite technologies, ab, whose slope, -dq/de, measures the efficiency foregone (at a constant cost) in return

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enhances d^ through a change in v, for constant x and w^c.

26. In each case the new technology is compared to the technology in use with a given level of material inputs, pure surveillance inputs and employment rents; the adjective efficient, monitoring and homogenizing pertain only to that comparison.

27. The monitoring and homogenizing aspects of new technologies may be added to Murray Brown's four fold characterization of technologies, and thus to the now ample list of bases for classification of technical change.

28. Or $px_o = px_a = px_b$. Alternative technologies will generally be characterized by different optimal levels of v and w^c but assuming them identical does not limit the generality of the example as the argument (but not its graphical representation here) is independent of the levels of these variables.

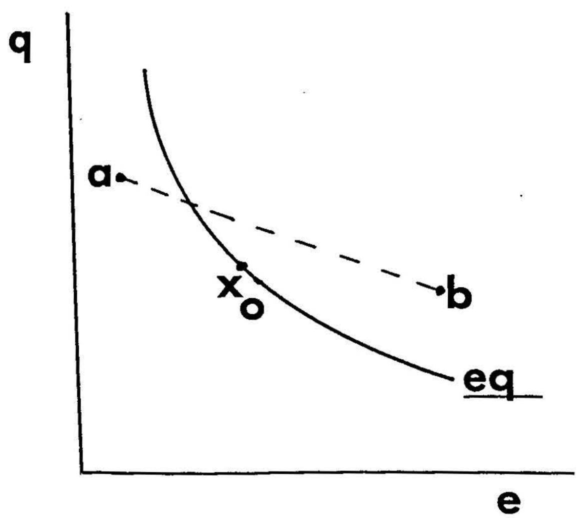
for an increment in work per hour.[29] Because the slope of the iso output per hour locus is just -q/e, the optimal choice of a composite technology will take place where

(9) $dq/de = q/e$

Equation (9) bears the suggestive implication that if (as seems probable) q rises secularly and e remains relatively constant in the long run, the profit maximizing choice of technology will entail the ever increasing sacrifice of efficiency gains in favor of effort gains.

Figure 1

Ineffficient Technical Choice By A Profit Maximizing Firm



We have considered the case of homogenizing technologies above, and the practical importance of efficient technologies is beyond question. Are monitoring technologies historically important, or are they little more than a logical possibility? Does the choice of production technology substantially alter the ease with which employers may acquire information concerning the work

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29. Assuming that this locus lies outside of the point x_o (which it need not, of course.)

activities of their employees?

The most common form of monitoring technologies are those which make up what Richard Edwards terms technical control systems of labor management.[30] "Machine paced production" does not generally compel the worker to maintain a particualr pace of work, rather it makes it immediately clear when the worker has failed to keep up the pace. Thus, an automobile assembly line may be considered to be a technology with a joint product: cars and information on deviations of each worker from the established work norm.[31]

Monitoring technologies need not be machine paced, however.[32] Contemporary word processeeing and data processing technologies now afford the employer a complete account of the computer operator's keystrokes per second, corrections per page and the like. In retail trade the cash register is being replaced by the point of sale terminal -- the more general contemporary terminology suggesting that it is more than the flow of money that is being controlled. The bar code scanners (automated cash registers) now widely in use at supermarkets allow employers not only a full record of each sale (for inventory and other accounting purposes) but a complete record of each checker's rate of processing of sales. Transportation companies now use satelite technology and small computers in buses and trucks to keep track of their drivers location, speed, and amount of time not in motion.[33]

The impressive monitoring capacity of new technologies does not imply that the control of the pace of work by employers will be enhanced in future years or will be secured at less cost. Powerful counter-monitoring tendencies are also at work, ranging from worker resistance to surveillance to the growing and now

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30. He distinguishes this from simple control and bureaucratic control. See Edwards (1979).

31. It also makes it possible for a small group of workers to disrupt an entire production process. It is perhaps for this reason that assembly line work rarely incorporated craft workers with high replacement costs. One wonders if assembly line work would have gained even the limited popularity it did in the 20th century had the craft workers maintained the barriers to their own replacement which had protected them during the 19th century.

32. I am here drawing on a report by 9to5 (1986), and Gary Marx and Sanford Sherizen (1986).

33. Further study of these and similar examples may reveal the extent to which these new technologies are actually used, and with what effect. For example, I do not know if bar code scanners are used for monitoring work, but only that they have the capacity to be used in this way. More is known about the use of data processing and word processing technologies for monitoring purposes, but I am aware of no systematic and comprehensive study of their use.

quantitatively predominant importance of employment in services rather than goods production, coupled with the simple fact that monitoring work output in the production of goods (where the output is readily measurable) is considerably simpler than in services. The difficulty in measuring and monitoring flows of information, however, gives rise to enforcement costs not only in labor relations but in product markets as well. To these we now turn.

Commodity Rights Enforcing Technologies: Hybrid Corn and Genetic Engineering

If the objective of labor homogenizing technologies is to make any given group of workers replaceable, the goal of commodity rights enforcing technologies is just the reverse, to make the firm's product irreplacable by detering the production of copies or substitutes.[34] Setting aside theft, nonpayment for commodities exchanged and similar common difficulties, the problem of commodity rights enforcement arises whenever the the cost of reproducing a commodity is small relative to the cost of production. Where this is the case the buyer of the commodity is immediately in a position to become a low cost competitor with the original producer. Commodity rights enforcing technologies attenuate this problem by raising the reproduction cost of the commodity.

We may model this problem in a particularly simple way. Consider a firm which is the sole producer of a commodity whose unit costs of production are c_p per unit, and whose costs of reproduction by a purchaser of the commodity are c_r. If the firm sets its price to limit entry to its market, as in the usual limit pricing model, and if the price markup which is just sufficient to attract this entry by a competitor is $m^\sim$, then the limit price selected by the firm must be $p < c_r(1 + m^\sim)$.[35] But if the firm must make at least the same markup as its potential competitor in order to finance its activity and remain in operation it must also be true that $p \geq c_p(1 + m^\sim)$, which clearly implies that the firm will only produce the product in question if $c_r \geq c_p$. The producing firm will generally have superior marketing and credit resources and most likely other advantages as well not reflected in this example. But the constraining effects

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34. Commodity rights enforcing technologies are discussed insightfully by Simon Avenell (1986).

35. Nothing but simplicity of exposition hinges on the use of the limit pricing model. A more general treatment would make the degree of enforcability of commodity rights a determinant of the extent of competition in the market for the product, and hence of the elasticity of demand facing the firm, and its optimal markup. The more general model yields identical results to that adopted in the text.

of the reproducibility of a commodity are quite clear nonethless, even if less binding than these simple assumptions would imply. Successful commodity rights enforcing technologies raise the ratio c_r/c_p. A <u>pure commodity rights enforcing technology</u> will raise c_r/c_p without altering other characteristics of the commodity.

The ubiquity of the commodity rights enforcement problem (and perhaps the lax moral stance of the author vis a vis property rights in cultural and intellectual goods as well) may be suggested by the fact that as I write these lines on a word processing program for which I paid nothing, occasionally making reference to photocopied passages from books which I did not purchase, I am listening to a symphony which I taped free from a friend's record. I am benefiting from the fact that, in this area, new technologies are as likely to raise as to lower enforcement costs. Unlike the older sound reproduction technologies, digital records and tapes, for example, can be copied endlessly without loss of sound quality. Video cassette recordings of films and television shows place VCR owners (90 million in the U.S. alone) in competition with the major networks and Hollywood.

Commodity rights enforcing technologies which have been developed in these areas are costly, ineffective, and often easily overriden by other commodities.[36] Bron Records, Ltd. in England introduced an inaudible signal -- called a spoiler -- on its records which would interfere with home taping. However, Thorn EMI Ltd discontinued its efforts in this direction when it learned that at least one tape deck manufacturer was adding an anti spoiler bypass device to its products. Warner Communictions Vice President Stan Cornyn commented ruefully: "Once the sound waves are out, you can't control them." Analogous efforts by the film industry -- Embassy's "Macrovision" system, for example, which distorts the sound and picture of copies -- have proven easily thwarted by professional duplictors. Technical measures to enforce commodity rights in computer software appear to have spurred at least equally creative and effective responses from would be free users.

A far more successful case of the technical enforcement of commodity rights -- and one of far reaching current and future ramifications -- has been documented in the exceptionally interesting recent studies of Jean-Pierre Berlan and Richard Lewontin.[37] As Berlan and Lewontin point out, the seed industry is a prototype

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36. See for example, Aljean Harmetz (1986), and "Sound Pirates" (1981). The quote from Cornyn below is from the latter source.

37. See especially (1986) and (1985).

case of the commodity rights enforcement problem:[38]

> Seeds are a special kind of factor of production because at least potentially they are reproduced in the production process itself. Thus, in principle, a farmer could produce his own seed by withdrawing a small portion of his crop from the market. The problem for the seed company is to convince the farmer not to do this...

Seed companies could achieve this objective, by

> creating seeds that are consumed in the production process: by providing seeds that are not really seeds in the biological sense that they are self-reproducing.

Berlan and Lewontin's compelling analysis of the development of hybrid corn suggests that it was this non-reproductive characteristic of hybrids, not higher yields which initially induced the seed companies to develop this product. John Barton had earlier noted this admirable characteristic of hybrids:[39]

> (Because) ... the seeds of the hybrid crop will not breed true to type, the farmer cannot effectively reuse the seeds. ... from the viewpoint of the seed producer, this annual requirement for new seeds provides a form of economic protection that is more effective than a patent system.

The enforcibility of commodity rights in hybrid corn was not some happy byproduct of a research agenda directed solely towards enhancing yields. Donald Jones, whose early 20th century research was critical to the development of hybrids, understood exactly what he was doing. Describing the hybrid variety, he and his co author wrote (in 1919),[40]

> it is something that might easily be taken up by seedsmen; in fact it is the first time in agricultural history that a seedsman is enabled to gain the full benefit from a desirable origination of his own...The man who originates devices to open our boxes of shoe polish or autograph our camera negatives is able to patent his products and gain the full reward for his inventiveness. The man who originates a new plant which may be of incalculable benefit to the whole country gets nothing... for his pain, and the plant can be propogated by anyone. ... The utilization of first generation hybrids enables the originator to keep the parental types and give out only the crossed seeds, which are less valuable for continued propagation.

Jones had no illusions concerning the superiority of hybrids from the

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38. Berlan and Lewontin (1986), p. 785.)

39. Barton (1982), p. 1071.

40. Cited in Berlan and Lewontin (1985).

standpoint of yields; moreover recent theoretical research implies that appropriately developed inbred lines will be higher yielding than hybrids. That the decision to develop hybrid varieties almost exclusively was not taken on the basis of yields is also suggested by the fact that even after a decade of intensive research and development the best hybrids were not outperforming the best open pollinated varieties.[41] If we are to agree with Zvi Griliches, the most noted student of the development of hybrid corn, that it was "one of the outstanding technological successes of this century," it may be that unlike Griliches, we should honor it more as a commodity rights enforcing technology than as a contribution to agricultural productivity.[42]

The hybrid corn example may be considerably more general that it might seem. Contemporary DNA engineering, notes Barton, could repeat the hybrid case quite widely:[43]

> Plausibly, any seed might be designed to make it biologically impossible for a farmer to reuse his crop for seed purposes. Such an "innate plant patent system" could pose enormous social costs in a concentrated industry.

Whether the obstacles to the private appropriation of the gains to research and information production are overcome by commodity rights enforcing technologies or not, these activities will necessarily bear the imprint of capitalist institutions. Kenneth Arrow's assessment is now widely accepted:[44]

> To sum up, we expect a free enterprise economy to underinvest in invention and research (compared with an ideal) because it is risky, because the product can be appropriated only to a limited extent, and because of increasing returns in use. ... Further, to the extent that a firm succeeds in engrossing the economic value of inventive activity, there will be an under-utilization of that information as compared with an ideal allocation.

Conclusion

The case has been made that capitalist institutions will influence the development and application of technical knowledge; moreover the examples

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41. Even comparing the yields of hybrids entered in field trials by breeders with open pollinated varieties entered by working farmers, the superiority of the former in the late 1920s was not impressive. Berlan and Lewontin (1985), p. 23.

42. Zvi Griliches (1958), p.419.

43. Barton (1982), p.1072.

44. Kenneth Arrow (1962),p. 619.

introduced suggest that this influence might be of sufficient empirical importance to warrent our attention.

Whether the institutional patterning of technological change is sufficiently regular or well understood to allow us to speak of technical epochs, social structures of accumulation, or long term fluctuations in economic activity as homologous with the dominance of monitoring, homogenizing and commodity rights enforcing technologies would be a question also worth pursuing.[45]

Further, the dynamic analysis of the types of techical choice outlined here -- exploring the long term direction of technical change along the three dimensions introduced here, and the manner in which this evolution is influenced by union bargaining, the evolution of the welfare state, product market structures, the general spread of higher education and the expansion of the concept of both property rights and personal rights would enrich the analysis and undoubtedly point to lacunae in the present formulation of the problem.

Lastly, while I have here focused on the enforcement of claims in the labor process and in commodity markets, similar considerations apply to credit markets. Thus technologies which make the monitoring of management decisions less costly may be prefered by lenders but not by borrowers. Similarly technologies which dictate a high level of capital asset specificity in the sense that the productive equipment has few alternative uses and little market value once installed will augment claim enforcement costs for lenders as the firm's assets will be of little value as collateral. Thus the locus of control over technical choice -- in lenders, owners, or managers -- may have significant effects on technological evolution which in turn will alter the viability of competing forms of firm organization.

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45. This exploration would benefit greatly from the insights of Stephen Cohn's concept of an "official technology."

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