DUAL LABOUR MARKETS AND THE EFFECT OF INVESTMENT ON EMPLOYMENT AND HOURS IN THE UK MANUFACTURING SECTOR.

NUMBER 37

T. J. HAZLEDINE

WARWICK ECONOMIC RESEARCH PAPERS

DEPARTMENT OF ECONOMICS

UNIVERSITY OF WARWICK
COVENTRY

DUAL LABOUR MARKETS AND THE EFFECT OF INVESTMENT ON EMPLOYMENT AND HOURS IN THE UK MANUFACTURING SECTOR.

NUMBER 37

T. J. HAZLEDINE

November, 1973

The author would like to thank some of the participants in the Warwick Econometric Workshop for their fine comments.

This paper is circulated for discussion purposes only, and its contents should be considered preliminary.

I. Dual Labour Markets

If an observer of an economy can divide its labour force into two groups, such that the set of jobs habitually taken by one group has few or no elements in common with the set of jobs taken by the other group, he may say that the economy has a dual labour market. Dual labour markets become a problem when the working conditions, pay, and security of one group, often known as the primary labour force,are generally agreed by the members of both groups to be superior to those available to the other group - the secondary labour force, and yet these differences cannot be easily explained in terms of differences between the two groups in the innate quality of the workers.

Bosanquet and Doeringer (1973) have shown evidence that strongly suggests that the UK labour market is dual, working particularly to the disadvantage of traditionally poorly served groups such as blacks and women. The fact of duality, if it is such, does not lie easily with the predictions of neo-classical economic theory. Reich *et al*. write (1973, p.359) -

> "Orthodox theory assumes that profit-maximising employers evaluate workers in terms of their *individual* characteristics and predicts that labor market differences among groups will decline over time because of competitive mechanisms."

Since such groups as blacks and women are involved, it is tempting to suggest an explanation purely in terms of prejudice - employers may value discrimination as a 'good' for which they are prepared to sacrifice some profits, and I will suggest that easily recognizable differences between groups play an important part in the non-trivial matter of *maintaining* a dual labour market - but I feel that to explain the emergence and development of dual labour markets a theory is needed that is imbeddedin more rational phenomena, especially since a large proportion of the secondary labour force comprises white adult males who are not easily distinguishable from their fellows in the primary force.

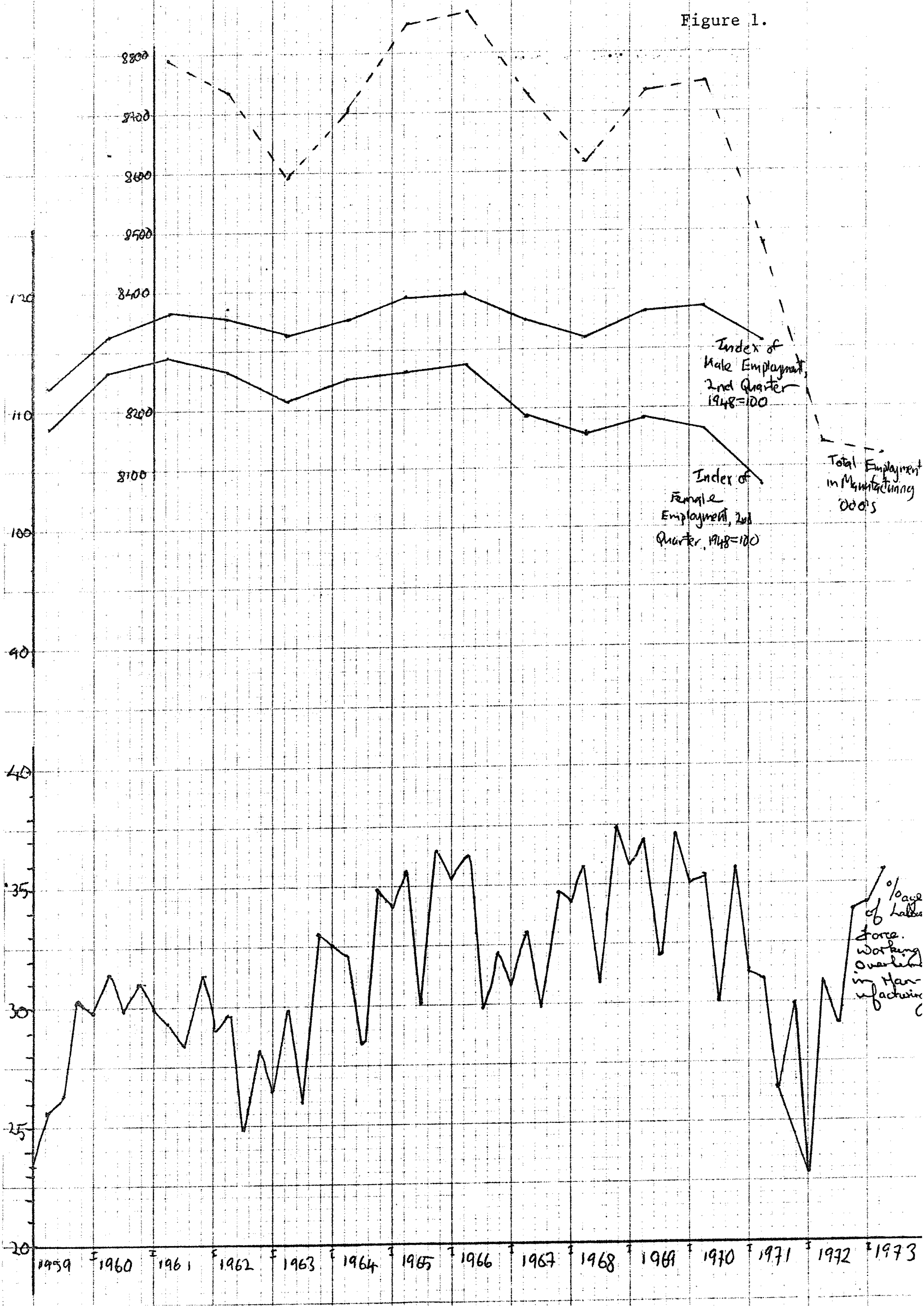
Reich et al. associate the primary work force with the concentrated corporate sector, and secondary workers with smaller competitive firms. The growth of big business explains the rise of primary workers, and the persistence of the secondary workforce is attributed to the existence of a residual amount of cyclically or seasonally unstable activities which the corporations prefer to leave to be undertaken by a more flexible competitive sector.

However, although this proposition helps explain why there is a distribution of job characteristics, it does not explain why this distribution should be dis-continuous, as is implied by the existence of duality. Firms cannot be divided into distinct 'corporate' and 'competitive' sectors. There is a quite fine distribution, in a mature industrial economy, of degrees of concentration between industries, and of sizes of firms within industries. Why should this great variety of scale and competitiveness generate two (or more) disjoint sets of jobs? This is the question to which I attempt to supply a plausible answer in the paper.

II. Recent Happenings in the UK Manufacturing Labour Market

On figure 1 are plotted the values taken by several important labour market variables at intervals during the period 1959 to 1973, for the UK manufacturing sector. Several interesting things seem to have been going on. The index of employment has a downward trend which steepens in 1970. The series for the percentage of the labour force working overtime appears to have a steady upward trend,(1) at least until the recession beginning in 1971. The size of the peak-to-trough-to-peak fluctuations in this variable was much greater over the cycle of 1971-73 than over any previous cycle in the observation period.

Figure 1.


8800
8700
8600
8500
8400
8200
8100
120
110
100
90
40
35
30
25
20
Index of Male Employment, 2nd Quarter 1948=100
Index of Female Employment, 2nd Quarter, 1948=100
Total Employment in Manufacturing '000's
1959
1960
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
1971
1972
1973

A good model of the labour market should be consistent with these events. In fact, I will suggest that they are closely connected with labour market duality.

III. The Model : Exogeneity Assumptions

I limit the range of the phenomena to be explained by taking as given three features of the world that are relevant to labour markets;

1. The capital/labour ratio

It is assumed that an industrialist planning investment in new plant has a rather narrow range of factor proportions from which to choose. This is quite plausible if industries are usually dominated at any time by one particular technique. Such a situation will tend to emerge, or, at least, be stable, if technological progress does not act to shift whole isoquants of factor combinations, but is 'lumpy' - improvements are centred around the techniques already known and in use - as suggested by Atkinson and Stiglitz. This is entirely reasonable if one believes, as do I, that most if not all technical change consumes resources in its development and introduction, so that it would be most costly to work at improving techniques on all fronts when only a small range of techniques is ever put into use.

This assumption, which amounts to ex ante fixed proportions, is illustrated in figure 2, which shows investment-labour isoquants for different rates of output. As drawn, the isoquants have some elasticity, but the points marked with crosses would dominate the others on the curves over a wide spread of relative factor prices. The spacing of the isoquants suggests returns to scale that at low rates of output are increasing, but which eventually decrease as the size of the investment projects becomes unusually large, and they require

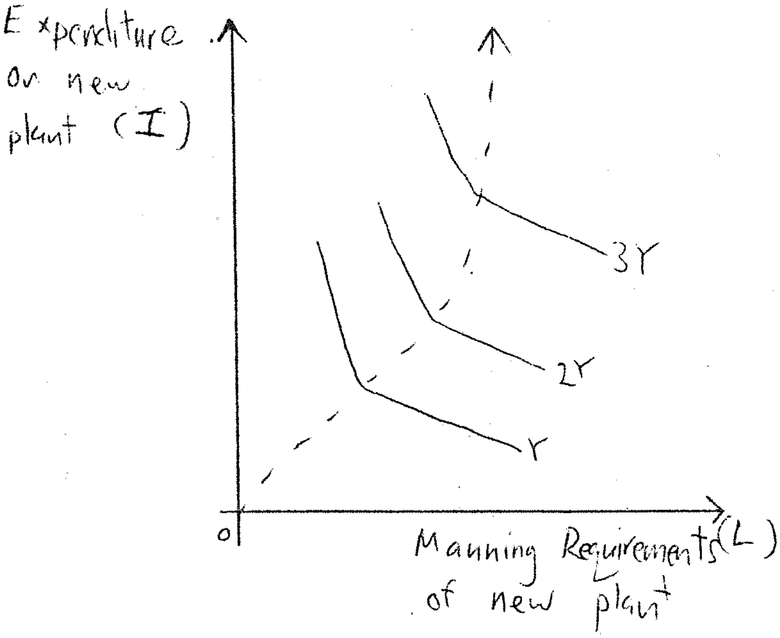


figure 2 : I-L Isoquants

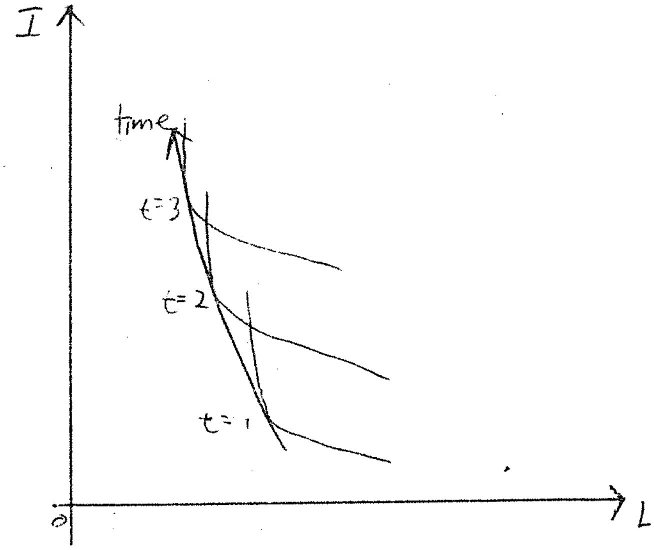


figure 3 : I-L per unit of output over time

relatively more attention, both in their design and construction, and in the elimination of teething problems.

So, the factor proportions of new plant is taken as more-or-less given in each industry at any time.[(2)] However, the proportions may be expected to change over time. In fact, the amount of capital per worker seems to have had a strong upward trend, however measured. For example, Heathfield's calculations (1972) for six SIC categories of manufacturing industries, using electricity consumption data to measure capital in use, reveal capital/labour ratios that, on average, more than double over the period 1955 to 1968. This is consistent with the I-L isoquants shifting over time as shown in figure 3.

The trend towards greater capital intensity may be due to a "natural drift", 'given by the direction of exogenous scientific discovery and invention'

(Nordhaus, 1973,p.215), but it may also be given as economic interpretation from the growth over time of the average size of firm, in pursuit of greater market power. As Penrose writes; ' ... a high capital-output ratio facilitates concentration' (1959, p.255n), because 'co-ordination of production activities is in general a simpler process when large machines instead of many people do the work' (1959, p.202), and the co-ordination, or 'control loss' problem increases with size.(3)

Control loss may also matter to investment decisions in a particular time period, so justifying the assumption in figure 1 of eventually decreasing returns to scale, which may be partially compensated for by increasing the investment/labour ratio so that the output expansion path may become steeper at high output rates, as drawn.

In summary, it will be assumed that at any time each possible output increase is associated with effectively unique factor proportions, and that these factor proportions change over time so that the investment/labour ratio increases.

2. The wage-payment system

The second relevant feature of the economy that we take as given is the institutional framework that determines the wage-payment system. It is assumed that workers receive a fixed weekly wage for working a number of hours up to what is known as the 'normal' number of hours - around forty a week. Hours worked in excess of normal hours are paid for on a hourly basis at the overtime rate, which is usually about one and one half times the 'ordinary time' rate obtained by dividing the fixed weekly wage by the number of normal hours, and are limited to a certain weekly number per worker - between ten and twenty in most industries. Beyond this number, either no more hours can be worked by each worker, or even higher, 'doubletime' rates come into effect.

We should qualify this assumption by noting that a small proportion of the work force may have to put up with being paid at an hourly rate while working fewer than normal hours - 'short-time' working,(4) and that many plants may be able to avoid the overtime constraint by working in up to three shifts each day, though shift workers will generally receive a premium for working their uncomfortable hours.

This wage-payment system is the result of many years of union-firm bargaining, and governmental law-making, and it is probably not unreasonable to consider it to be exogenously determined for the comparatively short period of time studied in this paper.

3. The boundaries of the firms' decision-making

Mainly for simplicity, I assume that the investment and employment decision-makers within firms take current and expected future sales as given, and see their job as to produce enough output to meet those sales at minimum possible cost.

IV. Investment and Manning Requirements

From III.3 above, we assume that the aim of the investing firm is to produce an output, Y, at minimum total cost.(5) Following III.1 and III.2, the cost function, C, is specified as (leaving out the time subscript)

$$C = \begin{cases} fE + wE\overline{H} + uEH, & \overline{H} > H \\ fE + (w + u)E\overline{H} + (pw + u)E(H - \overline{H}), & \overline{\overline{H}} \geqslant H \geqslant \overline{H} \\ fE + (w + u)E\overline{H} + (pw + u)E(\overline{\overline{H}} - \overline{H}) + (p'w + u)E(H - \overline{\overline{H}}), & \overline{\overline{\overline{H}}} \geqslant H > \overline{\overline{H}} \end{cases} \quad \ldots (1)$$

where f is the cost per employee of equipping a workforce with the latest capital, w is the ordinary-time wage rate, u is variable input costs (such as fuel) per worker-machine unit, p is the ratio of time-and-a-half or shift-working wage rates to w, p' is the 'double-time' rate, taken as infinite if double-time working is effectively not possible (for example if shifts are worked), H is hours worked per employee, $\bar{H}$ is normal hours, $\bar{\bar{H}}$ is normal hours plus the maximum number of time-and-a-half hours that can be worked, $\bar{\bar{\bar{H}}}$ is some ultimate limit on the number of hours that can be worked by an individual, and E is the number of Employees. E (and therefore investment, as well) and H are to be chosen so that costs are minimised.

We do need a production function, since there is a source of output variations that was abstracted from in figures 1 and 2; namely, that output will vary as the hours that the plant works varies. As well, the size of the labour force may affect productivity - to increase its labour force, a firm may have to take on marginally less experienced and lower quality workers. It may also be appropriate to consider the control loss effect in the production function.

Because it is easy to work with and as plausible as any other, the form of this ex ante production function is specified to be Cobb-Douglas, thus;

$$Y = aE^{\alpha} H^{\partial} \qquad \ldots (2),$$

where a is given by the productivity of modern plant at any time. Note, however, that our interpretation of the exponent of labour, α , is not the interpretation that would be given by an orthodox neo-classical analysis that had begun with an assumption of smooth capital-labour isoquants.

(2) is re-arranged to give E as a function of Y and H -

$$E = bH^{-\partial/\alpha} \quad , \quad b = a^{-1/\alpha} \; Y^{1/\alpha} \qquad \ldots (3),$$

and E is substituted into (1). The part of the cost function that will be of most concern is the portion over the range $\bar{\bar{H}} \geqslant H \geqslant \bar{H}$. In this region, then,

$$C = fbH^{-\partial/\alpha} + (w + u)bH^{-\partial/\alpha}\,\bar{H} + (pw + u)bH^{-\partial/\alpha}(H - \bar{H}) \qquad \ldots (4)$$

Differentiating this with respect to H, and re-arranging terms gives

$$dC/dH = -\partial/\alpha\,(f + w(1-p)\bar{H})bH^{-\partial/\alpha\,-1} + (1 - \partial/\alpha)(pw + u)bH^{-\partial/\alpha} \qquad \ldots (5)$$

The second derivative is

$$d^2C/dH^2 = \partial/\alpha\,(\partial/\alpha + 1)\,(f + w(1 - p)\bar{H})\,bH^{-\partial/\alpha\,-2} - \partial/\alpha(1 - \partial/\alpha)(pw + u)\,b\bar{H}^{\,-\partial/\alpha\,-1} \qquad \ldots (6)$$

We can set (5) equal to zero and solve for the value(s) taken by H at the extreme value(s) of the function, H^+ :

$$H^+ = \frac{\partial/\alpha\,(f + w(1 - p)\bar{H})}{(1 - \partial/\alpha)(pw + u)} \qquad \ldots (7),$$

and the second derivative at H^+ is

$$d^2C/dH^2\,(H = H^+) = \frac{b(\partial/\alpha)^{-(\partial/\alpha + 1)}\,(f + w(1 - p)\bar{H})^{-(\partial/\alpha + 1)}(1 - \partial/\alpha)^{\partial/\alpha + 2}}{(pw + u)^{-(\partial/\alpha + 1)}} \qquad \ldots (8)$$

(7) and (8) can be used to classify the cost functions into 4 categories, which are listed and illustrated in table 1. Equation (4) is, of

course, only the correct cost function within the range $\overline{H} \leq H \leq \overline{\overline{H}}$, and is drawn as a solid line within these limits, and as dotted lines outside them, where the correct expressions for cost when $H < \overline{H}$ and $H > \overline{\overline{H}}$ are drawn in.

The curve for costs when $H < \overline{H}$ can be quickly shown to always be downward sloping as H approaches $\overline{H}$; the portion for $H > \overline{\overline{H}}$ could be downward sloping beyond $\overline{\overline{H}}$, but it will be a harmless enough simplification to assume that it is not.

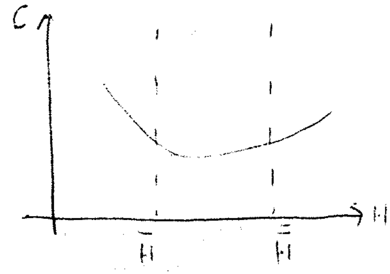
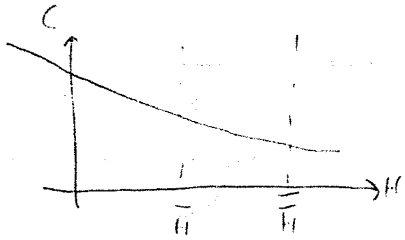
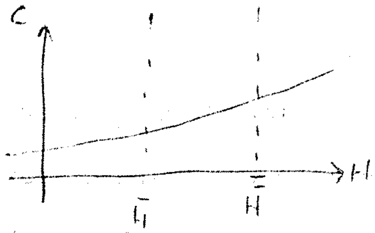
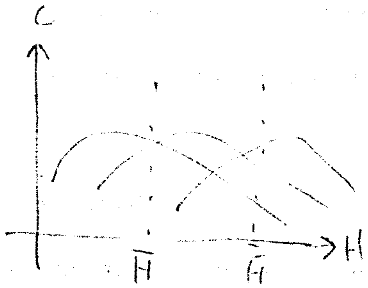
The implication of the slopes of C for $H < \overline{H}$ and for $H > \overline{\overline{H}}$ is that the cost-minimising number of hours per worker must always be ither $\overline{H}$ or $\overline{\overline{H}}$, or a number between them. In fact, perhaps a little surprisingly, only in category (i) can cost-minimisation require a number of hours between $\overline{H}$ and $\overline{\overline{H}}$ to be worked, since it is only in this case that the cost function can have a minimum value in the positive quadrant, and this will only occur when (4) has a minimum between $\overline{H}$ and $\overline{\overline{H}}$, as drawn.

For categories (ii) and (iii), and for category (i) when the minimum of (4) is outside the range $\overline{H} < H^{+} < \overline{\overline{H}}$, the sign of the slope of the cost function does not change between $\overline{H}$ and $\overline{\overline{H}}$. In these cases, only two values of hours per worker are relevant - $\overline{H}$ and $\overline{\overline{H}}$. It will either be optimal to work $\overline{H}$ or to work $\overline{\overline{H}}$. This is also true for category (iv), when C has a maximum between $\overline{H}$ and $\overline{\overline{H}}$, except in the odd case when $C(\overline{H}) = C(\overline{\overline{H}})$, when the employer will be in different between the two points.

What in fact are, and have been, the values taken by the parameters of the cost function that determine the number of cost-minimising hours to be worked per employee (and, therefore, the number of employees(6))?

We have noted the upward trend of the capital-labour ratio in manufacturing. This will be reflected by values of f - the cost of equipping a

Table 1 : The Cost Functions Categorized.

Category (i) $f+w(1-p)\bar{H} > 0$, $(1-\delta/\alpha) > 0$	$H^+ > 0$, a minimum, can be between $\bar{H}$ and $\bar{\bar{H}}$ $H^+ \to \infty$ as δ/α increases towards 1 $H^+ \to 0$ as $f+w(1-p)\bar{H}$ approaches 0	
Category (ii) $f+w(1-p)\bar{H} > 0$, $(1-\delta/\alpha) < 0$	$H^+ < 0$, $\frac{dC}{dH}(H>0) < 0$	
Category (iii) $f+w(1-p)\bar{H} < 0$, $(1-\delta/\alpha) > 0$	$H^+ < 0$, $\frac{dC}{dH}(H>0) > 0$	
Category (iv) $f+w(1-p)\bar{H} < 0$, $(1-\delta/\alpha) < 0$	$H^+ > 0$, H^+ a maximum, can be between $\bar{H}$ and $\bar{\bar{H}}$	

worker with new capital - that increase over time. Although such exercises are not to be taken too seriously, we can get some idea of the relative magnitudes of f and w from data on the value of capital per employee and on wage rates. Table 2 follows[7] -

	Capital/Employee, 1963 prices, £	Average fixed cost per employee for different payback periods (undiscounted)			Annual real normal hours wage rate per employee (adult male) £, 1963 = money wage
		3 years	5 years	10 years	
1949	2,025	675	405	203	550
1959	2,477	826	495	248	650
1969	3,262	1088	653	326	750

Table 2

The <u>ex ante</u> allocation of fixed costs per employee depends not just on the purchase price of capital goods, but also on the time period planned for the payment of the purchase price. Values of 'average fixed cost per employee' for different payback periods are shown in table 2. Of course, given the upward trend in the capital-labour ratio, the fixed cost per employee of new equipment will mostly be greater than the average, at any time.

It is perhaps possible to get some idea of the length of the average pay-back period by comparing data on depreciation or 'consumption' of the capital stock with the value of the stock. These data are shown, as far back as consumption figures go, in Table 3. The ratio of the two variables is shown in column 3. This ratio gives some idea of the rate at which firms are allowed by the tax laws to 'write-off' their plant in their financial accounts, which in turn should bear some relation to the rate at which firms plan internally to pay off their investments in new plant (and buildings). The figures in

	1	2	3
	Capital Consumption in Manufacturing; 1970 prices (Blue Book 1973, Table 59) £m	Gross Capital Stock at 1970 Replacement Cost (Blue Book) £m	Column 1 / Column 2
1962	799	30300	.0264
1963	831	31300	.0266
1964	869	32500	.0267
1965	906	33800	.0268
1966	945	35200	.0268
1967	986	36500	.0270
1968	1028	37900	.0271
1969	1071	39500	.0271
1970	1118	41100	.0272
1971	1160	42500	.0273
1972	1192	43800	.0272

Table 3, Capital Consumption and Stock

column 3 imply that about 2.7% of the value of capital stock is written-off in depreciation each year. This is a surprisingly low percentage, suggesting that plant life may be better measured in decades than in years, but it is supported by the figures given for the average age of equipment in Engineering industries in the Census of Metal Working Machine Tools.(8)

Discounting the future due to uncertainty and time preference should shorten the *ex ante* planning horizon, in which we are interested, from the *ex post* average age of plant, but we may still have to assume that the relevant period for the calculation of fixed costs per employee for new plant is as long as ten years.

What conclusions can be drawn from these, admittedly very imprecise, calculations, about the sign of $f + w(1 - p)\overline{H}$, or, of $f - 1/2w\overline{H}$, assuming the over-time premium, p, is $1\frac{1}{2}$? Two seem to follow from Table 2 :

(1) given a spread of fixed costs and wage rates per employee around the

means shown in the table, there is probably some plant for which $f - 1/2w\bar{H}$ is negative, and some for which it is positive;

(2) given that average fixed cost has an upward trend, and that this trend is steeper than the trend of real wage rates, the proportion of plant for which $f - 1/2w\bar{H}$ is positive has been increasing over the time period. This conclusion is slightly strengthened by the faint upward trend in the variable of column 3 in Table 3, which implies that the payback period has been shortening, and, so that, f has been increasing, ceteris paribus.

Now we consider the sign of $(1 - \partial/\alpha)$. The size of ∂ depends on the net effect of (a) 'set-up' time - time spent putting plant into operation each day - and, (b), fatigue, which reduces the marginal productivity of hours as the number worked in a day or a shift increases. Studies of the productivity of hours have assumed or concluded that ∂ is normally slightly less than one; say, 0.8 or 0.9.[9] - that is, that there are slightly decreasing returns to hours per worker. To the extent that older processes are craft or assembly-line based, so that work on them may be more mentally and physically tiring, respectively, than work on modern plants, which may involve more un- or semi-skilled routinized activities tending continuous process sytems in good working conditions, then ∂ may have increased over time.

As for α ; craft workers, with their generalized skills, and unskilled assembly workers, may be relatively quickly adaptable to different jobs, whereas the skills of the attendant of modern automated plant, although not usually intrinsically difficult, may be specific to the particular process they are learnt on, and not be so readily transferable to the plants of other firms. If so, α will be decreasing over time, due to the greater importance of on-the-job learning time, and, perhaps, a greater difficulty, when expanding the work force, in finding the 'right type of chap' to be entrusted with the care of increasingly expensive machinery.

So, for the older sort of plant, given the usual 'pool' of a few per cent of the workforce unemployed, the returns to changing employment when new plant is being set up are probably constant, or nearly so, whereas for the plant that is nowadays typically invested in, α may be appreciably less than one.

All this implies that the manufacturing sector has been steadily moving from a situation predominantly described by category (iii) on Table 1, in which plant was planned to be worked for the normal-hours week of the work-force, to the position represented in category (ii), where it is expected to work the maximum number of overtime hours (or to introduce shift-working).

To summarise this section on Investment and Manning Requirements;

(1) although the values of the cost and production parameters are probably quite 'continuously' distributed, the associated work force will not be - ot will be divided into two rather discrete groups, those working just normal hours and those working the maximum number of hours[(10)] - , and

(2) the proportion of workers in the second group has been increasing over time

V. Short-term Cost Minimisation

The manning requirements E^+ and H^+ are optimal for the planned rate of output, Y^+. However, we do not rule out the possibility of output diverging from its planned rate after the plant appropriate to E^+ and H^+ has been installed and of variations in E and H to meet these *ex post* fluctuations. What we now wish to examine are the optimal values for E and H, E^* and H^*, for values of Y, in the short-term; that is, for periods short enough for plant to be effectively fixed.(11)

First, we must specify the short-term production function. There seems to be no reason to suppose the form of the relationship between hours worked per employee, H, and output, to be different in the short-term function and the long-run, or ex ante function (2). On the other hand, the relation between E and Y should be very different in the short-term, with capital fixed, than in (2), which is assumed that capital varied with E. I propose that the relationship between output per manhour and employment in the short-term is generally something like one of the curves drawn in figure 4 - productivity

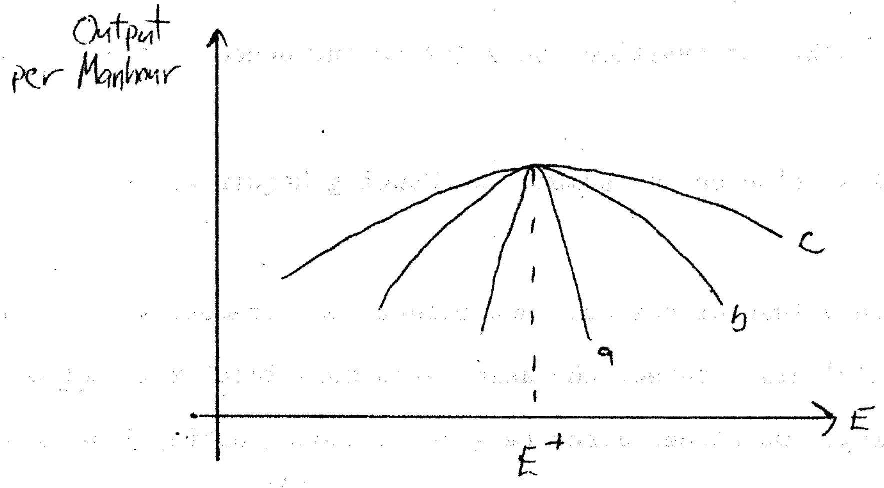


Figure 4; Output per Manhour

is at a peak when employment is at the ex ante optimal, designed for, level E^+, but declines for values of E below or above E^+, when plant is 'under' or 'over' -manned. This hypothesis about the form of the short-term production function is discussed more fully in Hazledine (1974).

The above remarks suggest that the short-term production function, be written

$$Y = g(E)H^{\partial} \qquad \dots (9),$$

or, assuming, for simplicity in what follows, constant returns to hours -

$$Y = g(E)H \qquad \ldots (9)'$$

If the output per manhour curve in figure 4 could be represented as a quadratic, then g(E) in (9)' would be a cubic function of E[12]

The short-term cost function is

$$C = \begin{cases} w E\overline{H} + wEH , & \overline{H} > H \\ (w + u)E\overline{H} + (pw + u)E(H - \overline{H}) , & \overline{\overline{H}} \geqslant H \geqslant \overline{H} \end{cases} \qquad \ldots (10)$$

which is simply (1) with the fixed cost term fE removed, and the possibility of $H > \overline{\overline{H}}$ ignored, for expositional simplicity.[13] For notational simplicity, in what follows we will not both to write down the conditions on H.

Unfortunately, attempts to minimise (10) subject to (9)', quickly get bogged down in a morass of high-order terms in E or H, even if g(E) is simply cubic. A more heuristic approach to the determination of E^* and H^* is necessary.

First, from (9)', we substitute for H in (10) -

$$C = \begin{cases} wE\overline{H} + uYE/g(E) \\ w(1 - p)E\overline{H} + (pw + u) YE/g(E) \end{cases} \qquad \ldots (11)$$

Average cost is,

$$C/Y = \begin{cases} wE\overline{H}/Y + uE/g(E) \\ w(1 - p) E\overline{H}/Y + (pw + u) E/g(E) \end{cases} \qquad \ldots (12)$$

and marginal cost, holding E constant, satisfys

$$\partial C/\partial Y = \begin{cases} uE/g(E) \\ (pw + u)E/g(E) \end{cases} \qquad \ldots (13)$$

These curves are drawn on figure 5. Had we bothered to specify C for $H > \bar{\bar{H}}$, the curves would have been as drawn for $Y > \bar{\bar{Y}}$, where $\bar{\bar{Y}}$ and $\bar{Y}$ are the output rates, given E, at which H equals $\bar{\bar{H}}$ and $\bar{H}$.

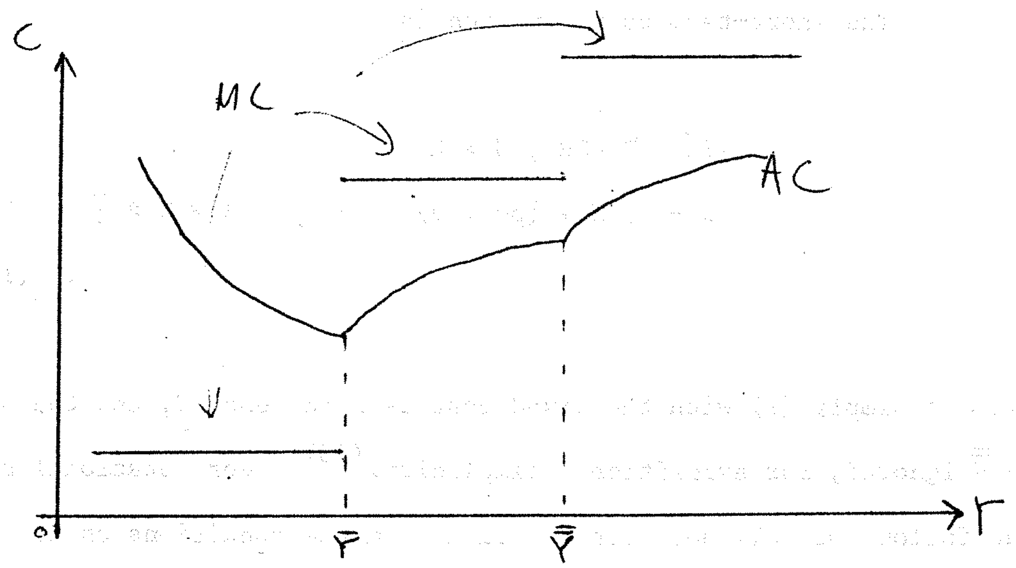


Figure 5 ; Cost Functions for Y given E

To accomplish analytically the analogous task of obtaining AC and MC functions holding H constant and varying E would be much more difficult, since it would entail inverting (9)' to get E in terms of H and Y. In any the analysis should become more complicated, since although it may be reasonable to specify that H enters the short-term production function similarly for all sorts of processes, this is not, I think, plausible for E. That is, g(E) is probably not to be taken as a constant function for all ages and types of plant. In particular, the capital-intensity of production should matter in the short-term, as it did in the analysis of <u>ex ante</u> production possibilities of section IV.

The output rate of sophisticated, capital-intensive plant may be determined relatively more by its specification when installed and less by its interaction with the production labour force than more labour-intensive, typically older, plant. Automated or continuous-process plant operates at speeds, set by its designers, which may not be advanced much by additions to the labour force attending it, and which may not permit reductions in its labour force, on pain of something possibly going very wrong with the system at some unattended point.

To carry the analysis further, I shall pretend that processes can be divided into two polar categories, called 'traditional' and 'modern'. The characteristics of the modern category are outlined in the previous paragraph, and imply the cost functions drawn in figure 6. Increases in E beyond E^+ will only increase output very slightly above Y', where $E = E^+$, given H, whereas the fact that the plant has a minimum manning requirement at or near E^+, to be violated only at risk of costly breakdowns, implies that substantial reductions in output can be obtained only by working fewer hours than are paid for,

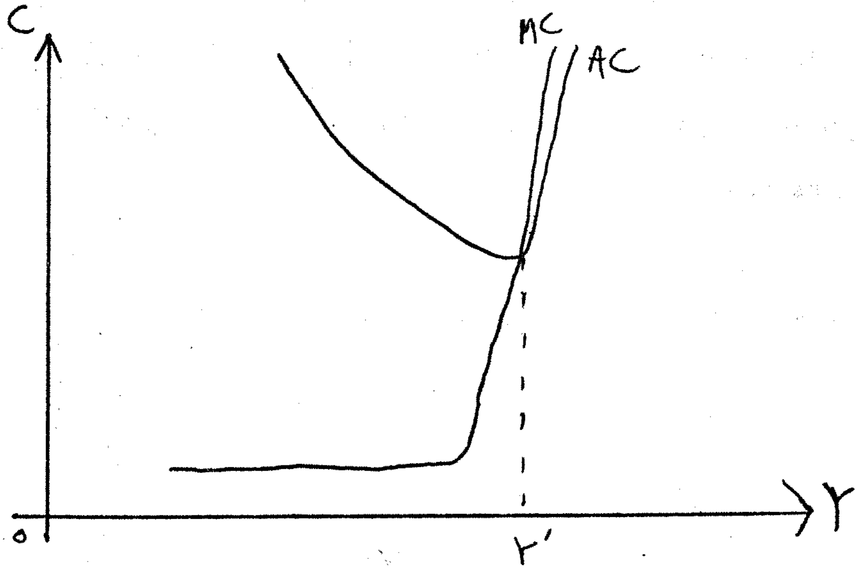


figure 6 ; Cost Functions for Y give H : Modern Plant

at a cost-saving only of materials and fuel. If material and fuel costs (u) were zero, the AC curve would be simply a rectangular hyperbola, and the marginal costs would be zero, to the left of Y'.

On the other hand, traditional, labour-intensive plants are probably more 'people-paced' - less 'machine-paced' - than modern operations, so that the output rate fluctuates quite freely with the size of the labour force. This seems certainly true for assembly-line processes such as those in the motor industry, which records substantial fluctuations in its output rates due to variations in turnover, absenteeism, and industrial relations problems, and may be equally plausible for craft industries, such as building, in which most of the wherewithall of value added is supplied by the worker itself - his skills and his tools.

This suggests that the output per manhour curves for traditional plant are much flatter than those for modern plant - say curve c on figure 4, rather than curve a. What will the cost curves look like? For ourputs above Y', they will slope upwards, but much more gently than curves for modern plant. For Y less than Y', cost curves for individual plants will slope upwards, but for the traditional category or sector as a whole, costs can be reduced with output by closing down the least efficient plants.(14) The net effect on costs is unknown <u>a priori</u>; for simplicity I assume that AC and MC is constant over a range of Y less than Y'.

Thus we have the cost functions for traditional plant, H constant, drawn in figure 7.

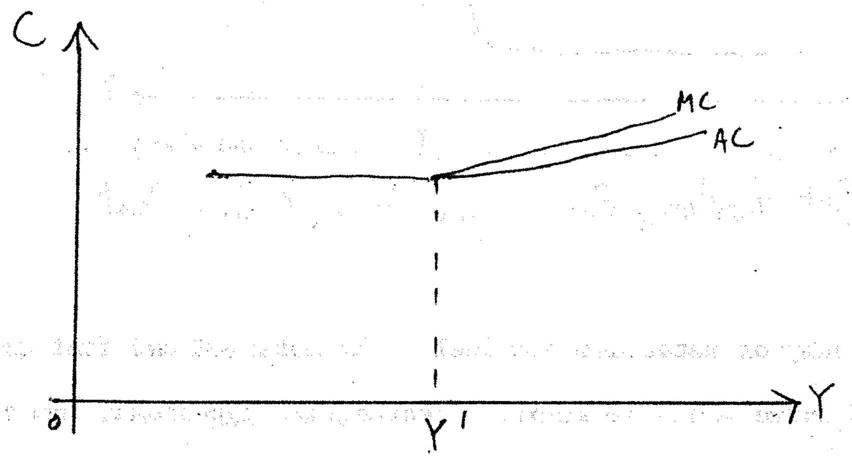


Figure 7: Cost Functions for Y given H; Traditional Plant

To summarize the story of Section V so far: The aim is to derive expressions for the short-term cost-minimising values of E and H, E^* and H^*, but an analytic solution to the optimising problem is not readily forthcoming. We promise to, at least partially, circumvent this difficulty by drawing cost functions for Y; (a) with H varying, E fixed, applicable to all types of processes, (b) with E varying and H fixed, which were drawn separately for 'modern' and 'traditional' production processes. To what use can these curves be put? Consider figure 8 -

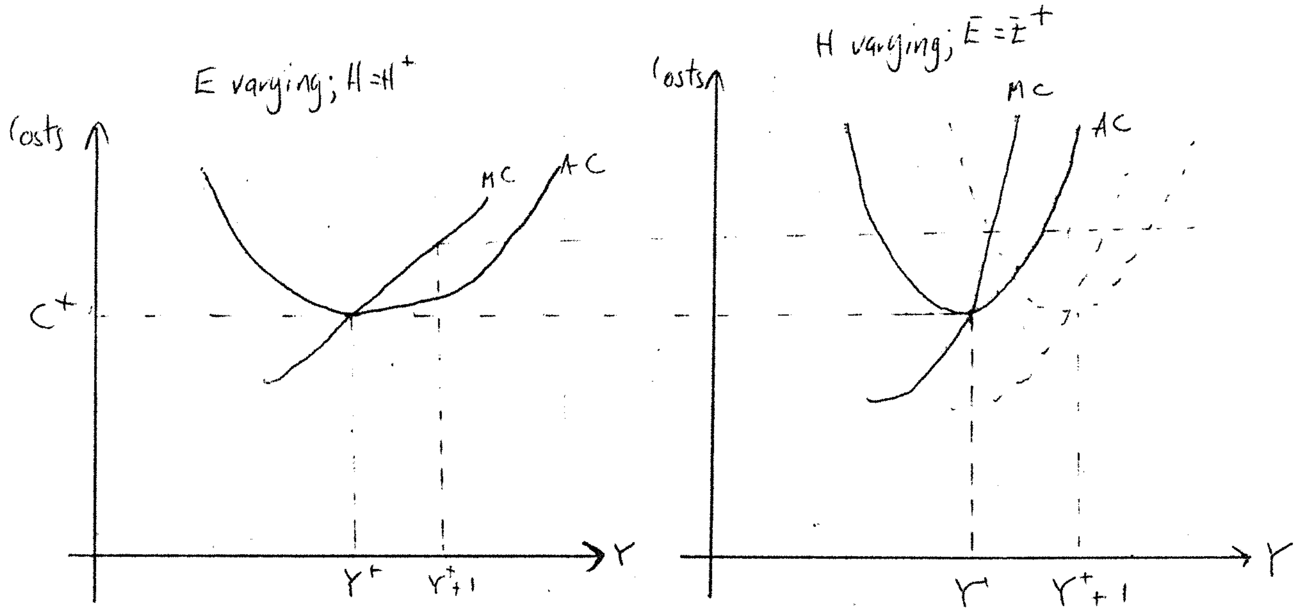


Figure 8 ; Cost Curves around Y+

on which are drawn conventionally shaped AC and MC curves. Clearly, if Y^+ is an output attainable with $E = E^+$ and $H = H^+$, all four curves - AC and MC, E-varying, $(H = H^+)$, and H-varying, $(E = E^+)$ will take the same value at $Y = Y^+$. Suppose that Y is initially Y^+, and is being produced with the lowest-cost factor combination (E^+, H^+), when an increase in Y by just varying H, is called for. How will this be done at minimum cost? We can approximately describe the solution of the cost-minimising problem as an iterative procedure. Consider increasing Y first by one unit, to $Y^+ + 1$. Since the E-varying cost curves are flatter than the H-varying curves around Y^+, get to $Y^+ + 1$ by just increasing E, to E^+_{+1}. Now a new H-varying curve has to be constructed, for $E = E^+_{+1}$. If the H-varying curves do not depend on E, the new curve will just be the old one moved horizontally to the right by one unit. Otherwise, the curve will probably shift up as well as to the right, if there are diminishing returns to E. In any case, the E-varying MC at $Y^+ + 1$ may now be greater than the H-varying MC, as drawn. If so, get the next increase in Y but just varying H, then compute new E-varying curves given the new value of H, and compare them with the H-varying curves to decide what to do about the third step in increasing Y, and so on.

With the cost curves as drawn in figure 8, about all that can be said about the effect on E^* and H^* of a change in Y is that both E^* and H^* will change, with more variation in the factor for which the MC curve is flatter around Y^+ (E in figure 8). However, our polar assumptions about traditional and modern plant will pay for their restrictiveness by allowing us to make much more detailed predictions about the responses of E^* and H^* to changes in Y.

Consider first the case of traditional processes. We draw in on the same axes the cost functions with H varying, E constant, of figure 5, and with E varying and H constant, (figure 7). We take the constant E and H to be E^+ and H^+ respectively. For simplicity we call the marginal cost curve with E varying and $H = H^+$, $MC(E)_{H^+}$, and so on. Figure 9 follows.

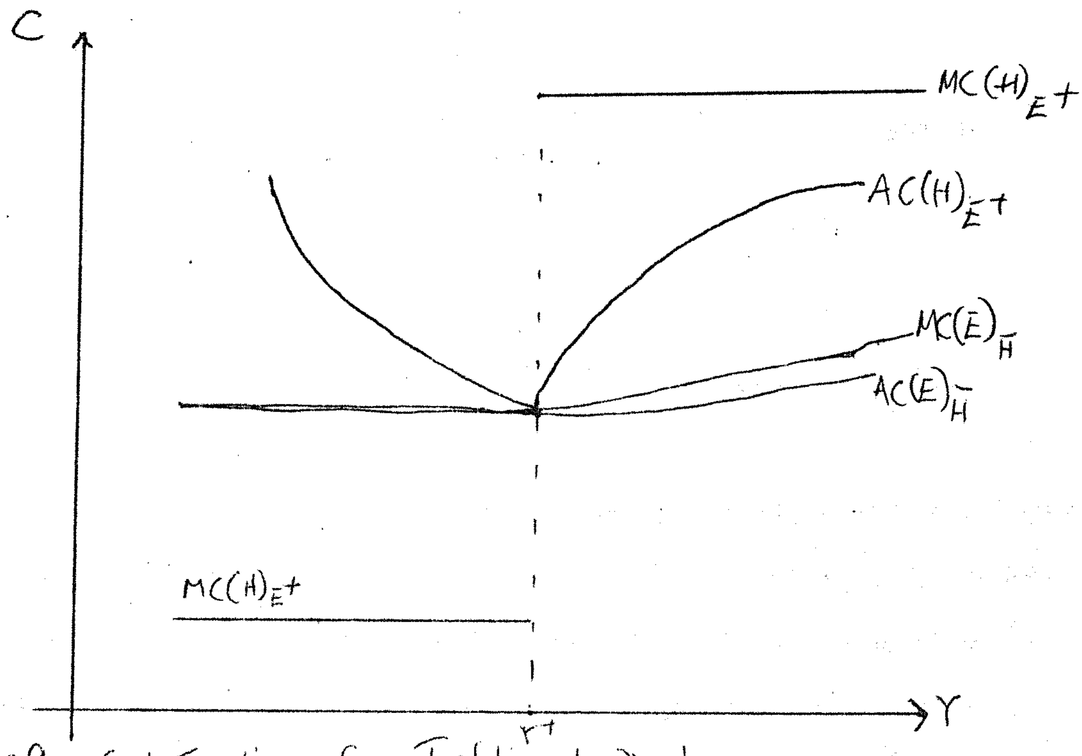


Figure 9: Cost Functions for Traditional Plant

Clearly, it will be cost-minimising to meet at least small fluctuations above or below Y^+ by varying E alone, since to the right of Y^+, MC(E) is below MC(H), and to the left it is below it. In fact it is probably so that a reduction in Y of <u>any</u> size will only affect E, since the horizontal cost curves in this region are consistent with g(E) = mE in the production function (9)'[15], in which case, the MC functions given by (13) are not dependent on E, which cancels out. What about costs to the right of Y^+? A plausible specification of (9)' suggested by figure 7 is

$$Y = nE^{\theta}H \text{ , } 1 > \theta > 0, Y > Y^+ \qquad \dots (14),$$

which re-arranges to

$$E = (Y/n)^{1/\theta}H^{-1/\theta} \qquad \dots (15).$$

(15) can be substituted into (13), and into (10), so that the $MC(E)_H$ function

can be derived. It turns out that for $H = \overline{H}$, and for increases in Y above Y^+,

$$MC(E)_{\overline{H}} = (\frac{w + u}{\theta})n^{-1/\theta}\ \overline{H}^{1-1/\theta}\ Y^{1/\theta\ -1} \qquad \ldots (16),$$

and

$$MC(H)_E = (pw + u)n^{-1/\theta}\ \overline{H}^{1-1/\theta}\ Y^{1/\theta\ -1} \qquad \ldots (17).$$

The optimal factor input levels depend on the size of $\frac{w + u}{\theta}$ relative to pw + u. For example, if material and fuel costs, u, were insignificant then expansion above Y^+ would be affected by changes in H and not E only if returns to labour, θ, are less than 2/3 (assuming $p = 1\frac{1}{2}$), which is probably not so for quite large increases in Y.(16) If $H^+ = \overline{\overline{H}}$ (as assumed in figure 9), then, given the higher double time premium, expansion above Y^+ would <u>a fortiori</u> tend to be taken out in increases in E only. However, contractions might result in decreases in H.

Still, remembering our definition of the traditional sector as comprising typically older, less capital-intensive plant, and the results of section IV relating H^+ to capital-intensity, it is probably reasonable to associate what I have called the 'traditional' sector with values of H^+ predominantly equal to $\overline{H}$.

So for traditional plant, we conclude that the short-term cost-minimising response to fluctuations in output is to vary E^*, but not, or not much, H^*, which will be constant at $\overline{H}$ (= H^+).

For 'modern' plant, we draw a very different conclusion. In figure 10, cost curves from figures 5 and 6 are super-imposed on the same axes analagously to figure 9. In the case of modern plant it can be seen that, outside a rather narrow range of variation of Y around Y^+, the marginal cost functions are such that changes in Y will be optimally generated entirely by changes in H^* (assuming, as drawn, that the capital-intensity of modern plant is sufficient for H^+ to be set at $\bar{\bar{H}}$. Also, given the steepness of MC(E) at values of E around E^+ (where $Y = Y^+$), the effect on the cost minimising decision when MC(E) is re-calculated, according to our exemplifying iterative procedure, for different values of H, will be small or non-existent.

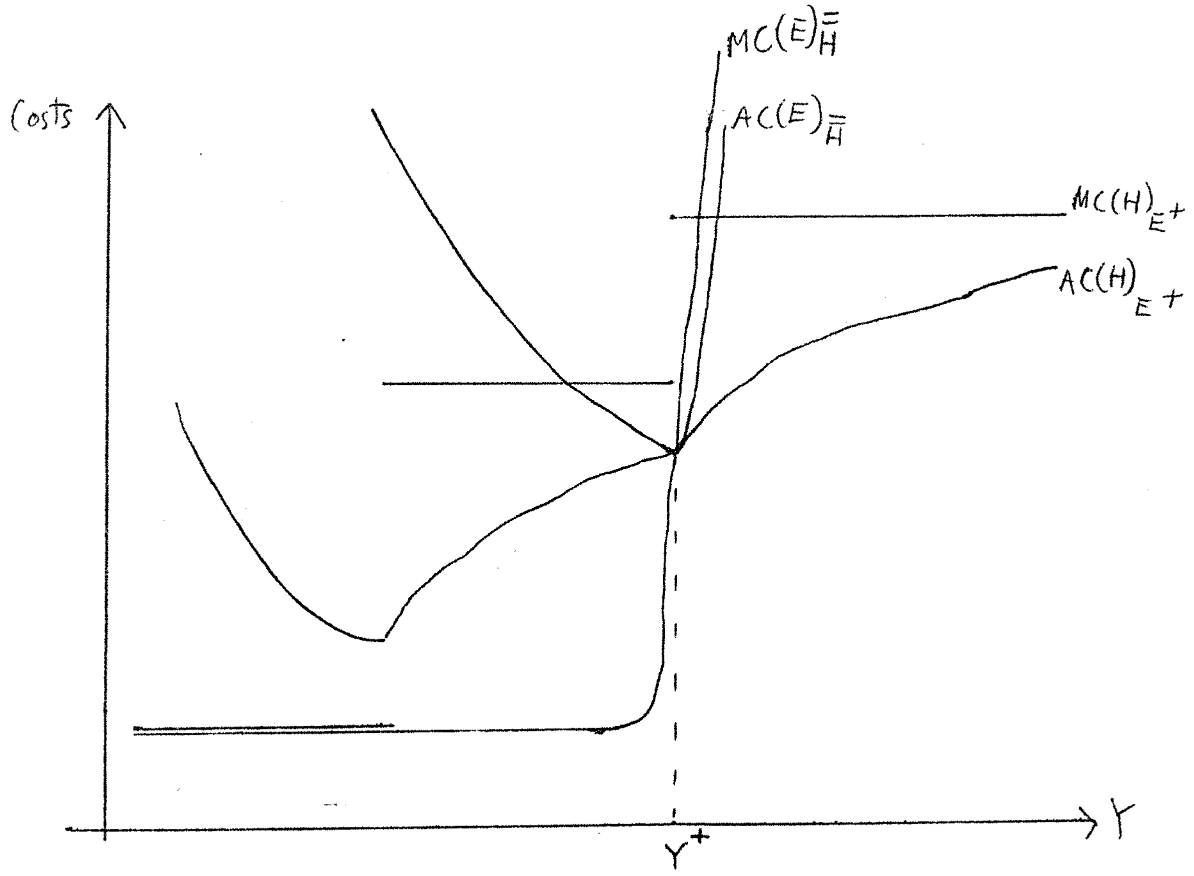


figure 10: Cost Functions for Modern Plant

Thus, in contrast to the result for traditional plant, our conclusion about modern processes is that H^* will depend on Y, but not, or hardly at all, E^*, which will stay close to E^+.

VI. Observed Fluctuations

I think of employers' decision-making about employment and hours as taking place on three levels. The first level, considered in section IV, is tied to long-term decisions made about investment in new plant. The second concerns the desired way of utilising plant once it is fixed in place, given short-term fluctuations in demand. This was analysed in the previous section. Thirdly, we should recognize, although it is not of central importance to this paper, that observed values of variables will, in general, differ even from those desired in the short-term, due to costs attached to the implementation of decisions to change the level of employment, or the rate of hours worked. The study of these 'adjustment costs' is the basis of the literature on Employment Functions, and is continued in Hazledine (1974).

VII. Confronting the Evidence

I have developed a theory of the influence that the capital intensity of production has on the employment and utilisation of the labour force. Is this theory consistent with the observations we have on labour market variables? We return to Figure 1. We know that capital intensity has been increasing (cf Table 2). Therefore, according to the model of section IV, output per employee should have been increasing both as each worker was given more capital to work with, and as the number of employees working longer hours increased. We see that while the output index has risen since 1959, total employment in manufacturing has tended to fall. Also, the proportion of the labour force working overtime has an upward trend.[17]

The implication of the short-term analysis of section V is that, as the proportion of 'modern' plant has increased, the proportion of cyclical fluctuations in desired labour input that is met by varying H rather than E will have increased.[18] Inspection of the data seems to support this hypothesis, too. The size of the peak-to-trough-to-peak fluctuations due to the recession of 1971-72 in the percentage of the labour force working overtime was much larger than the fluctuations observed over any other period in the sample.

What about my notion of duality itself - the prediction that the workforce will be divided into two, rather separate, groups; one group working only normal hours, the other working the maximum number of overtime hours (or shifts) with not many people in the intermediate category? Again, I find the evidence encouraging.

	Working Overtime					Not Working Overtime			%age working Overtime
	Normal Hours Worked	Average Overtime Hours Worked	£ Earnings excluding overtime	£ Overtime Earnings	£ all-pay Hourly Earnings	Hours Worked	£ Earnings	£ Hourly Earnings	
Full-time Manual Men (aged 21 and over)	40.1	9.6	25.3	7.6	0.664	40.1	28.6	0.713	57.9
Full-time Manual Women (aged 18 and over)	39.1	4.5	15.5	2.2	0.406	39.1	15.3	0.391	17.8

Table 4: Overtime Working in Manufacturing; April 1971
(Source: Dept of Employment Gazette, February 1972, Tables 97, 98, 99)

For men doing overtime work, Table 4 shows that the average per caput number of overtime hours per week was 9.6 in April 1971. Given that the average would probably be lowered by the presence of some overtime being worked in response to short-term fluctuations in demand, and adjustment costs, such as bottlenecks, it seems plausible to me that those plants which were operating at or near their ex ante planned rate were, indeed, working either no overtime, or the maximum amount, at the time of the survey.

The evidence on earnings is interesting. I had expected that workers on newer plant (where $H^+ = \bar{\bar{H}}$) would have been able to win for themselves higher hourly earnings than other workers, because of their average productiviity, given the greater amount of capital per worker, and because employers would wish to pay a wage premium to discourage turnover, in view of the presumed higher training costs associated with manning the more capital intensive plant.(19)

However, table 4 shows that, although weekly earnings are higher, amongst men, for overtime workers, their normal-time hourly rate is, in fact, substantially lower. This difference does not seem to be merely a consequence of aggregating data, since it persists, in nearly every case, when the sample is broken down in MLH industries, and into occupational groups. Furthermore, the difference remains, although it is much smaller, when we compute total weekly earnings divided by total weekly hours for the two groups.

The implication is that leisure is an inferior good - if it is associated with a decline in the marginal revenue of an hour's work, employees will accept overtime, and so reduce leisure time, in order to increase total weekly earnings. Reinforcing this may be the attitude of employers if the marginal productivity of hours declines as the working day is lengthened (that is, if $\delta < 1$).

Apart from its sign, the fact of a persistent difference in hourly earnings is in itself further re-inforcement to the acceptance of duality - of disjoint labour forces - in the economy, if, as seems to me plausible, it is unlikely that two men of the same occupation working together in the same plant could be paid at different basic hourly rates because one was working overtime and the other not.

VIII. The Composition of the Dual Labour Forces

The existence of duality may not matter much if 'primary' and

IX. The Employment Multiplier

Figure 2 was drawn to suggest that doubling the output from investment in a time period may typically involve more than doubling the expenditure on investment, but less than doubling manning requirements, because engineers may be only able to produce really big new systems if these are relatively capital-intensive.

Various regression equations were estimated. Since the specification and data for these regressions need a lot of improvement, I will only show, at this stage, one of the more promising equations.

Using quarterly data for manufacturing from 1959 I to 1973 II, the change in the number of operatives over each quarter, ΔM, is regressed on a constant, time, change in real output, ΔY, expenditure on investment at current prices, I, and I^2, the number of operatives employed at the end of the previous period, M_{-1}, and a host of seasonal and data dummy variables.

The result is (t-ratios in parentheses) -

$$\Delta M = \underset{(-0.5)}{-118} - \underset{(-4.3)}{-8.1T} + \underset{(2.5)}{14.4\Delta Y} + \underset{(3.4)}{3.3I} - \underset{(-2.9)}{0.0029I^2}$$

$$- \underset{(-2.3)}{0.081M_{-1}} + (\text{dummy terms}), \quad \bar{R}^2 = 0.61, \quad D\text{-}W = 2.1 \qquad \ldots (18)$$

The constant term is insignificantly different from zero, as one might wish it to be in a regression with the change in a variable dependent; the negative coefficient of time probably reflects 'disembodied' technical change, ΔY allows for cyclical influences on employment, and M_{-1} for adjustment costs. The coefficients of I and I^2 are both significant, and are of opposite sign.

(18) implies that the partial effect of investment on manning requirements is as drawn (approximately) on figure 11.

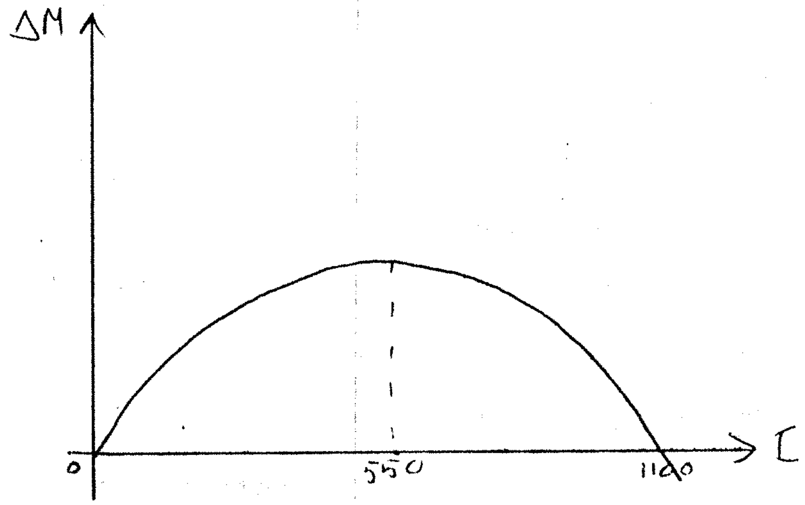


Figure 11 : Effect of Investment on Manning Requirements

Increasing investment up to 550 increases employment, but at a decreasing rate. Beyond I = £550m, further boosts in investment will be associated with a <u>decline</u> in the addition to employment.

There are some qualifications to this prediction. ΔM is the <u>net</u> change in employment, which includes both changes due to investment in new plant, and those due to the scrapping of old plant. If all investment was associated with the scrapping of old plant, we would expect the coefficient of I to be negative, given the upward trend in the capital-labour ratio. However we have no evidence that this is so.

As a determinant of <u>changes</u> in employment it might be better to use investment net of replacement investment, and its squared value, in place of gross investment.

Only the most recent current-price figures for investment are as high as 550, so that although the upward-sloping part of the quadratic seems quite stable, statistically, predictions about the ΔM resulting from investment greater than 550 are extrapolations beyond the previously observed range. The fact that current price variables do better (in terms of t-ratios) than constant-price variables may itself be a bit of a puzzle.

Much more work is needed[20], which may support my tentative suggestion based on figure 11, that in the UK successful attempts to boost the rate of investment may only result in the substitution of capital for labour, with a positive effect on unemployment, instead of the negative effect presumably intended; all this, perhaps, for a small or even negative change in GNP.

If this is so then the acceptance, under the present price controls, of intentions to investment (such as B.L.M.C's £500m plan) as a justification for price increases, and the public approval (and partial financing) of big investments such as the British Steel Corporations £3,000m project, should be critically examined.

Note that equation (18) is an attempt to explain the same phenomenum-short-term changes in employment - that is the concern of the literature on 'employment functions' (cf Ball and St. Cyr 1966 , Hazledine 1973). Since (18) differs from employment function specifications in its inclusion of the investment variables and the change in output (which does better in my regressions than the level of the rate of output, Y), it may have some implications for this work.

However, the $\bar{R}^2$ of equation (18) is not tremendously impressive. A particular source of mis-specification is presumably the inconsistency of (18) with the analysis of sections (IV) and (V), which implies that the relationship between ΔM and its explanatory variables has not been constant over the time period. Given the difficulties of estimating relations with changing coefficients, the best course of action may be to estimate the relation for shorter time periods. Using data dis-aggregated at the industry level should also help with this problem, as well as enabling some much richer tests of the predictions of this paper.

X. The Flexibility of the Economy

The switch from 'traditional' to 'modern' processes may have serious implications for the cost at which the economy can adjust to cyclical fluctuations in aggregate demand conditions. We recall that differences in the specification of g(E) in the short-term production function (9) were shown to imply that modern plants would react to short-term output fluctuations by varying H only, whereas adjustment in traditional plants would tend to be concentrated on changes in E, with H held constant. Since we did not assume any differences between traditional and modern processes in the exponent δ of H in (9), and have no particular reason to do so, traditional plant could vary output by varying H only at no greater relative cost than that suffered by modern plants. Since, however, they choose (according to the analysis of section V) to vary only E, this must be less costly to them than varying H. The implication of this is illustrated in figure 12, which shows average cost curves for two plants - one traditional and one modern - with the same <u>ex-ante</u> optimal output rate, Y^+. Costs at $Y = Y^+$ may well be lower for the modern plant, but the discussion of this section suggests that the AC curve for traditional plant will be the flatter of the two around Y^+ so that for Y sufficiently different from Y^+ modern plant costs will be higher than traditional. During recessions we may prefer the tendency of modern plant to hang on to its labour force, but during booms, even though the higher costs of modern plant are not social costs - they are costs to employers of a redistribution of income towards wage-

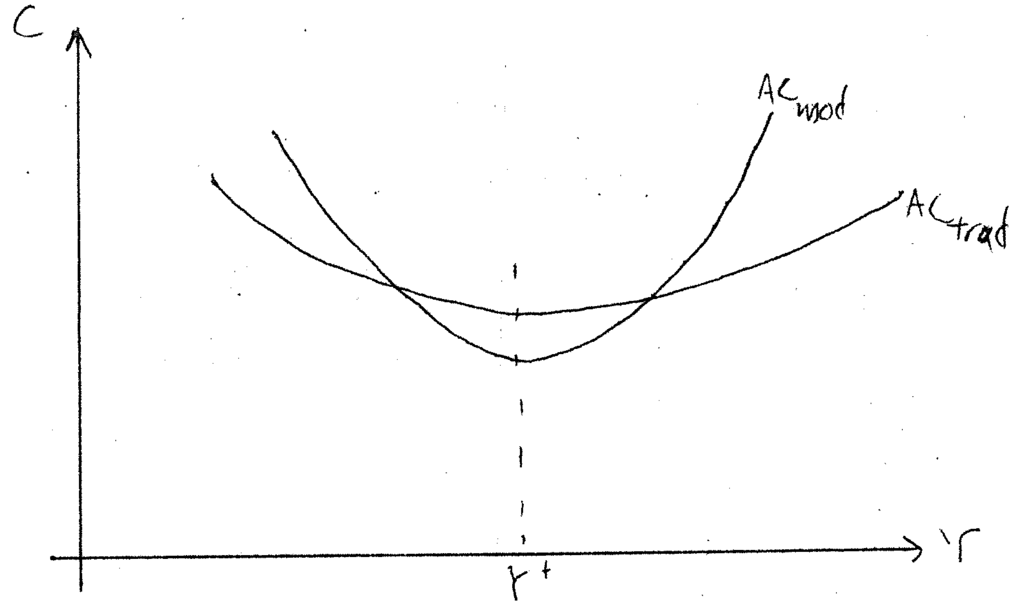


figure 12: Average Cost Curves for Traditional and Modern Plant

earners in overtime payments - they may add to the desire and ability of firms to react to increases in money demand by raising prices instead of real output.

If the ex-ante optimal number of hours per man, H^+, on modern plant is close to the upper limit attainable, then an economy in which the importance of the modern sector is increasing may be decreasingly able to use fiscal and monetary policy to raise output and employment above Y^+ and E^+, even if these should be such that GNP and employment were considered by all parties to be too low.

Footnotes

(1) A simple regression of the % working overtime on a time trend (T = 1, 2, 3, ...) for the period 1959I to 1970IV gave the equation

$$\text{\% Working Overtime} = \underset{(36.3)}{27.3} + \underset{(6.6)}{0.176T} \qquad \bar{R}^2 = 0.462$$

(t-ratios)

Including the (as yet incomplete) cycle beginning in 1971 just about halved the coefficient of T and its t-ratio.

(2) We do not assume that factor proportions are the same for all industries.

(3) Nordhaus himself writes elsewhere (1969, p.19): 'Most descriptions indicate that a great deal of process improvement goes toward increasing the optimal size of machinery'.

(4) Over the period, the percentage of operatives on short-term seldom exceeded 2% of all operatives.

(5) The decision problem is not quite as simple as this if the firm has to decide between producing on new and on old plant. This doesn't matter here, though, since output does not appear in the relations we derive for optimal H.

(6) Note that H^+ is not a function of Y, though E^+ obviously will be.

(7) Table 2 is calculated from data contained in various Blue Books and publications of the Department of Employment and Productivity.

(8) Cf Bosworth (1972, 1973) for information on, and references to these censuses.

(9) Hart (1973) refers to a Prices and Incomes Board study which suggests that 'higher use of overtime tends to lower, slightly, productivity per man-hour in many industries or leave it unchanged' (p.76).

(10) An industry or firm moving smoothly from category (iii) to (ii) will have to pass through either (i) or (iv). If it goes through (i), then there is a possibility of some number of overtime hours between $\bar{H}$ and $\bar{\bar{H}}$ being chosen ex ante, but this will be transitory. Of course, cyclical and adjustment-cost factors may cause ex post fluctuations in overtime hours between $\bar{H}$ and $\bar{\bar{H}}$ these we consider in the next sections.

(11) Disposals of plant and machinery in manufacturing in 1968 were worth £53 million in total; about 0.25% of the replacement value of the stock of plant and machinery in that year. In contrast, the number of discharges (labour turnover) in 1968 was about 30% of the average labour force in manufacturing. So it seems that, compared to labour, capital is rather fixed once installed.

(12) Though the problem of labour quality referred to in section IV implies that output per manhour would not be a (symmetric) quadratic function of E.

(13) The wage cost specification in (10) is similar to that in Ball and St. Cyr (1966). Dropping fixed costs is only completely acceptable if these are dominated by capital costs (that is, if training and other labour fixed costs are relatively small).

(14) We suppose that, once installed, all modern plant has a higher productivity than at least some traditional plant, so that, except in extreme recessions, the modern sector would not reduce output by closing down any plant - traditional plant would always go first.

(15) Using the term 'production function' loosely, since we are now talking about a whole sector, not single processes.

(16) The specification $g(E) = E^{\alpha}$ is inadequate in that it implies, AC functions not horizontal at Y^+, so that MC at Y^+ is above the MC curve drawn in figure 1.

(17) The Department of Labour enquiries into shift working reinforce this, since they found that the percentage of workers who were shift workers in manufacturing rose from 12% in 1954 to 20% in 1964.

(18) Note that the polar assumptions of 'traditional' and 'modern' plants are not meant to be taken literally, especially since I have criticised this sort of dichotomising in the work of Reich _et al_. There will in fact be a distribution, perhaps a quite fine one, of short-term characteristics. The true source of _duality_, I have suggested, lies in the wage payment system. Nevertheless, it is clear from our descriptions that plants for which $H^+ = \bar{\bar{H}}$ will tend to be at the 'modern' end of the scale, and those for which $H^+ = \bar{H}$ at the 'traditional' end, and in what follows, I sometimes talk of 'modern' and 'traditional' plants as though these were in discrete categories.

(19) It is probably consistent with this that recruitment and training costs as a percentage of total labour costs in manufacturing rose from 1.4 in 1964 to between 1.8 and 2.3 in 1968 (sources : Department of Employment and Productivity publications)

(20) Not least in establishing a proper dynamic model of the full Keynesian multiplier effects of a change in investment. I suspect that the real output (and employment) multipliers are now rather small, due to the prevalence of product market monopoly power in the UK economy.

Bibliography

Atkinson,A.B., and J.E. Stiglitz, (1969), "A New View of Technological Change", Economic Journal, 573-578

Ball,R.J., and E.B.A. St Cyr, (1966), "Short Term Employment Functions in British Manufacturing Industry", Review of Economic Studies, July, pp. 179-207

Bosanquet,N., and P.B. Doeringer, (1973), "Is there a Dual Labour Market in Great Britain?", Economic Journal, June, pp. 421-435

Bosworth,D.L., (1973a), "Production Functions and Skill Requirements", Paper given at the Conference on Manpower Forecasting, University of Warwick, July.

Bosworth,D.L., (1973b), "The Theory of Production: Evidence from the U.K. Engineering Industry", Ph.D. Thesis Proposal, University of Warwick, August.

Hart,R.A., (1973), "The Role of Overtime Working in the Recent Wage Inflation Process", Bulletin of Economic Research, May

Hazledine,T.J., (1974), "Employment and Output Functions for New Zealand Manufacturing Industries", Journal of Industrial Economics, forthcoming.

Heathfield,D., (1972), "Factor Substitution: Some Empirical Results for Six U.K. Manufacturing Industries", Discussion Paper No. 7250, University of Southampton

Nordhaus, William D., (1969), Invention, Growth, and Welfare, The M.I.T. Press

Nordhaus, William D., (1973), "Some Skeptical Thoughts on the Theory of Induced Innovation", Quarterly Journal of Economics, May.

Penrose, Edith, (1959), The Theory of the Growth of the Firm

Reich, Michael, David M. Gordon, and Richard C. Edwards, (1973), "A Theory of Labor Market Segmentation", American Economic Review, May; pp. 359-365.