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BRITISH MANUFACTURING PRODUCTIVITY 1955-1983: MEASUREMENT PROBLEMS, OIL SHOCKS AND THATCHER EFFECTS

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ABSTRACT

There has been considerable controversy over the apparent slowdown in productivity growth in Britain and in other industrial countries over 1971-80 and the apparent speed up in at least British productivity growth over 1980-83. This paper throws light on these matters by means of an aggregate production function for British manufacturing estimated on quarterly data for 1956-83. This makes it possible to distinguish cyclical movements in productivity caused by variations in labour utilization from underlying trends. The measure of labour utilization rests on information on weekly hours of overtime work as a fraction of the normal work week. The paper also considers measurement problems in output for which several significant observable proxies are available and in capital, the latter being proxied by shifts in time trends. The utilization measure is compared with the CBI's capacity utilization data and Bennett and Smith-Gavine's Percentage Utilization of Labour index. Estimates are provided of measurement biases in output and comparisons made between crude output per head and a productivity measure corrected for variations in utilization and measurement biases in output.

JEL Classification: 226, 631, 641.

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NON-TECHNICAL SUMMARY

This paper provides estimates of an aggregate production function fitted to quarterly data for British manufacturing for 1956-83. The unusual features are its treatment of labour utilization and of biases in the measurement of output. These and the use of split time trends to proxy measurement biases in the gross capital stock data make it possible to distinguish underlying productivity growth from short term fluctuations in output per head. This throws a good deal of light on the apparent deceleration of British manufacturing productivity in 1973-80 and its apparent acceleration in 1980-83 following the 1979-80 crisis in manufacturing.

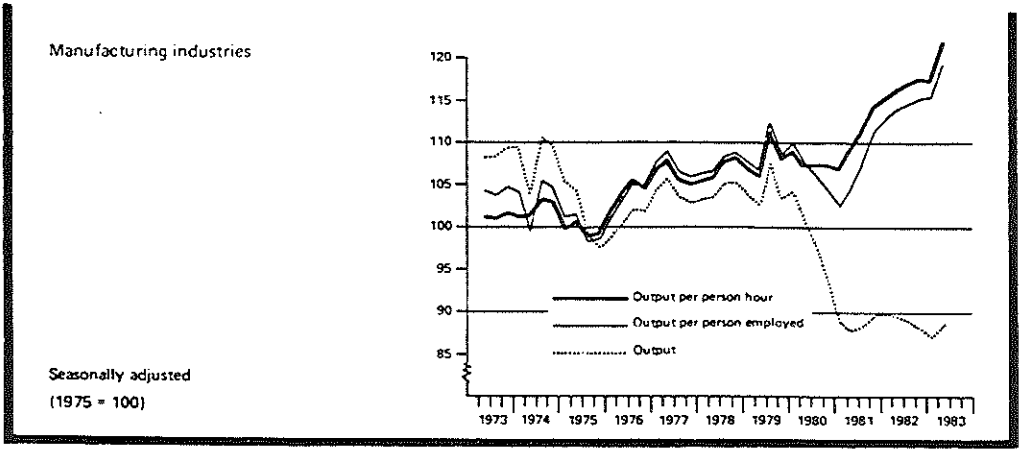
The measure of labour utilization is derived from data on overtime hours and gives excellent empirical results. It has a broadly similar cyclical pattern to the CBI's capacity utilization measure available from 1958.3 (1958 quarter 3) and Bennett and Smith-Gavine's Percentage Utilization of Labour index available from 1971.2. Four potential output biases arising from problems in the construction of the CSO's output index are considered. The 'gross output bias' has been suggested by Bruno (1984) and Bruno and Sachs (1982) as a major element in the productivity deceleration. Grubb (1984) disputes this and we agree: we estimate only about a 2% effect in 1974 relative to 1970. However, we find the 'domestic price index bias', the 'list price bias' and the 'price control bias' of considerable significance in interpreting short run movements in output per head.

Our estimates suggest an underlying trend rate of per annum productivity growth of 3.4% for 1955.1-73.1, 1.4% for 1973.1-79.3, -0.3% for 1979.3-80.3 and 2.9% for 1980.3-83.4. This suggests that both the 1973 deceleration and the 1980 acceleration were genuine. Our favoured explanation of both is in terms of unrecorded scrapping (or other productivity losses) of capital which came to a head in 1979-80 and then ceased. There are symptoms, though not statistically significant, of a slightly

faster underlying rate of productivity growth in 1983.

1. INTRODUCTION

To begin with recent productivity history, consider Chart 1 for the two major controversies of the decade 1973-1983. The first is about the effects of the first oil shock, which was also associated with peak prices for other raw materials relative to prices of manufactured goods. There certainly was a marked reduction in productivity levels in 1974 and 1975 and for the rest of the 1970's productivity grew more slowly than in the 1950's or 1960's. Similar phenomena have occurred in most industrial countries and have generated much discussion, see Lindbeck (1983) for a survey and Baily (1981, 1982), Bruno (1984), Bruno and Sachs (1982), Darby (1984), Denison (1983), Grubb (1984) and Raasche and Tatom (1981) for some of the key contributions. An important question is whether the productivity slowdown was simply a cyclical phenomenon of the extended recession which followed the oil shock or whether other explanations are important. Bruno suggests a kind of measurement error as a potential explanation: the increase in raw material prices would have caused substitution against raw materials so that gross output grew more slowly than value added. The more commonly used gross output based productivity growth measures would thus be downward biased. Darby suggests that for the U.S. most of the slowdown was due to distortions in the official price and output figures caused by the price controls introduced in 1971 and removed in 1974. The other favoured explanation advanced, for example, by Baily and Raasche and Tatom is that much of the capital stock in existence in 1973 was built to use techniques of production which became inefficient at a higher relative price of energy and other raw materials. This led to scrapping or productivity losses of capital which were not recorded in official statistics.



S18 SEPTEMBER 1983 EMPLOYMENT GAZETTE

Chart 1: source, Employment Gazette, September 1983, p.S18

The second controversy is primarily a British one but also raises the issues of distinguishing trends and cycles in productivity and that of unobserved scrapping of capital. There has been a great deal of economic and political comment on a set of Japanese style figures for productivity growth in British manufacturing beginning in 1981, see Chart 1. These figures have been cited as evidence of a productivity breakthrough which is not only a break from the past but a portent for the future. They have also been claimed as a success for the economic policies of Mrs. Thatcher's first administration.

According to the CSO's Economic Trends, from 1980.4 to 1983.1 output per head grew at 7.0% per annum and output per person hour at 5.9% per annum.* These figures certainly look dramatic relative to comparable figures for the decade 1970-1980 of 2.0% and 2.6% and for 1960-1970 of 3.4% for output per head. But doubts are raised when one notices that from 1979.4

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* The data refer to the 1968 SIC definition of manufacturing. All percentage rates of change in the paper are defined as 100 times the log-change, unless explicitly stated to the contrary.

to 1980.4 output per head actually fell by 6.6% while output dropped 16.2%. Such a rapid collapse of manufactured output has been exceeded only once in British history. As Hoffmann's (1955) figures reveal, this was in 1920-21.* Given the costs of making workers redundant and, no doubt, the hope that the domestic recession imposed on top of a World slowdown would not last, employment declined more slowly than output. Output per head therefore fell. Clearly a large part of the subsequent productivity growth was merely the recovery in output per head when output bottomed out in 1981 while employment continued to fall. However, there is more to the story as the figures for output per person hour suggest: there the decline between the last quarters of 1979 and 1980 was only 2.2%, substantially less than the subsequent improvement. Therefore it appears there was a genuine breakthrough of some kind. Jones (1983), who has examined a variety of published sources comes to a similar conclusion.

How did this breakthrough come about? Much has been made of examples from particular parts of industry such as British Steel and British Leyland. These suggest that two alternative mechanisms may have been operating. One is the once and for all "shake-out" of less efficient resources mentioned above. The other view proposes that the shake-out has brought about a new era of industrial relations in which power has shifted towards management, workers and unions being less able to engage in restrictive practices or resist the introduction of new technology. On the latter view, the rate of productivity growth should be permanently higher.

The published productivity figures used to argue permanence contain short-term cyclical variations in over and under-utilization of labour which can easily be misinterpreted as long-term improvements. It is well known

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*Then the return to Gold at the old parity, high interest rates, the loss of export markets as a result of World War I and domestic deflation combined to reduce industrial output by 37% and manufactured output by probably even more. As Buiter and Miller (1982) point out, not even the 1930's offered an experience comparable to 1979-1980.

that in temporary downswings in the business cycle, output per head always drops and that in the upswing output always increases faster than employment. Indeed 'Okuns Law' is a simple expression of this phenomenon which can also be seen in Chart 1. The reason for the phenomenon almost certainly lies in the costs of adjusting employment which make it worthwhile to hoard labour in temporary recessions and which penalize rapid hiring or firing of workers relative to more gradual adjustment.* One might have thought that reductions in observed hours of work would reflect labour hoarding. However, as Chart 1 makes plain, the cyclical pattern of output per person hour still follows that of output and of output per head though it is a little more attenuated than the latter. If one takes the view that firms are always on their production functions conditional upon established practices governing the allocation of labour within firms, this would suggest that observed hours do not adequately measure the true utilization rates of the inputs of firms.

How to correct crude productivity for variations in utilization is a problem with which most researchers on productivity have struggled at one time or another. One possibility is to side-step the problem by estimating an employment or production function with sufficient distributed lags to pick up short run dynamics (presumably related to variations in utilization) and to measure long run trends from the steady state solution. Chatterji and Wickens (1982) follow this route. Our experience, however, is that the long run solution is typically insufficiently well determined statistically to say anything decisive on shifts for a period as short as 3 or 4 years.

A direct examination of the relationship between outputs and inputs thus seems inescapable. Essentially this suggests estimating a production function on aggregate time series data. Though in the late 1950's and the 1960's there was a fashion in such exercises, nowadays one approaches it with some

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*See for example, Oi (1962), Fair (1969), and Sims (1974).

trepidation in view of three fundamental conceptual problems: the unobservables problem, especially with regard to utilization, the aggregation problem and the simultaneous equations problem. The view taken below is that the first is by far the most important which puts the onus on finding a good indicator for utilization.

Some writers such as Denison (1979) have used the cyclical deviation in the share of profits to remove the cyclical component in productivity movements. But in the British case this is likely to be sensitive to variations in wage push and in the real exchange rate that are not reflected immediately in utilization levels. Some like Baily (1981) have used unemployment rates but this confuses labour supply factors with utilization rates, particularly, as Grubb, Jackman and Layard (1982) have noted, in the British case. The Wharton approach of measuring deviations from trend output begs the question of what determines the trend, while Taylor's (1974) proposal of measuring deviations from trend productivity is circular in this context. The Jorgenson and Griliches (1967) proposal of using electricity consumption as a percentage of installed wattage has been used with some success by Heathfield (1972, 1983) in a study of the British engineering industry. However, it was criticised by Denison (1969) and may be sensitive to variations in electricity prices relative to other inputs. Baily (1981, 1982) has also tried lay-offs, deviations in the rate of change of utilization from trend and aggregate survey responses of firms asked whether they were operating below full capacity.

Our approach to measuring utilization is based on information on the overtime hours of operatives. In Section 2 below we sketch the theoretical rationale of this approach and discuss the derivation of empirical proxies for measurement errors in capital such as unobserved scrapping and in output which we also regard as important. This summarizes the methodological position on aggregate production function estimation set out in Muellbauer (1984). In Section 3 we present estimates of an equation for British manufacturing for the period 1956-83 and explain what can be learned from it about productivity change since 1955. Estimates of productivity change corrected for utilization and for some of the biases in the output measure are presented. Our utilization measure is compared with a capacity utilization series derived from the CBI survey and with Bennett and Smith-Gavine's Percentage Utilization of Labour. Conclusions are drawn in Section 4.

2. The Theoretical Background

For a constant returns production function, the rate of change of output is a weighted average of the rates of change of the inputs plus a technical change term. Aggregating such terms over firms into industries and over industries into aggregate manufacturing gives a relationship between the rate of change of the (real value added) index of output and rates of change of employment and the capital stock. But as well as an aggregate technical change term, there are aggregation bias terms. We are generally ignorant about aggregation biases across firms. But it appears that aggregation biases across sectors, which are small in theory when sectoral rates of change are roughly independent of sectoral weights tend to be small empirically.* For the Cobb-Douglas form to be a tolerable approximation to an aggregate constant returns relationship between aggregate output and aggregate labour and capital, abstracting from utilization issues, the elasticities of output w.r.t. employment need to be roughly constant. The share of labour in factor payments which, for a cost minimizing firm in a steady state, should give this elasticity has been fairly constant secularly, though it varies cyclically with utilization rates. Especially in view of the difficulties in measuring utilization and the capital stock, we regard the specification error from the Cobb-Douglas assumption as relatively minor in the kind of empirical exercise we pursue below.

Our approach to measuring utilization can be explained as follows: write a firm's production function

$$\ell n\, q_{it} = \text{const.} + \alpha_i\, \ell n(WW_{it}\, h_{it}\, \ell_{it}) + (1-\alpha_i)\, \ell n\, K_{it} + \theta_i t \qquad (1)$$

where q is output, WW measures the number of weeks worked per unit time, h is effective weekly hours of work, ℓ is employment, K is the capital

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*Less than one half of one percent respectively over the periods 1955-1970 and 1970-83 for British manufacturing. For the U.S., Jorgenson and Griliches (1967) also report small biases.

stock and θ stands for the rate of change in technology and work practices, unmeasured quality changes and aggregation biases. Now let

$$u_{it} = \ln h_{it} - \ln \bar{h}_{it} \tag{2}$$

where $\bar{h}_t$ is normal hours. We can observe above normal utilization rates when firms work overtime. But since firms that underutilize or 'hoard' labour usually still pay their workers for a standard week, underutilization cannot be observed directly. However, given a stable distribution of (weighted) utilization rates $\alpha_i u_i$ over firms, we can, on certain assumptions, deduce an average rate of utilization from the observed overtime. There is an analogy here with measuring aggregate excess supply Z from data on unemployment U but with data on vacancies V missing. Assuming a trade-off of the form $UV = c$, excess supply $Z = U - cU^{-1}$, see Hansen (1970). Making a corresponding assumption, we take average utilization to be

$$u_t = OH_t - c\, OH_t^{-1} \tag{3}$$

where OH_t is $\dfrac{\text{total overtime hours of operatives}}{\text{total no. of operatives x normal hours}}$.

However, an institutional point needs to be made here. Some of the reductions in normal hours in the 1950's and 60's were essentially a way of increasing wage rates. Thus 'normal' or systematic overtime, seen as part of the implicit employment contract increased. To adjust cyclical overtime for this, we include in (3) an interaction term between normal hours and OH_t^{-1}. This corrects the utilization level for increases in systematic and so non-cyclical overtime and can be seen in (5) and (6) below.

Turning now to the measurement of capital input, there are two main issues: whether capital should be adjusted for utilization and the validity of gross capital stock data. Kendrick (1973), Denison (1974) and Gollop and Jorgenson

(1980) argue that capital should not be adjusted for utilization. If their position is correct, then presumably capacity utilization measures based on surveys, such as the CBI's Industrial Trends Survey, can simply be regarded as measures of labour utilization. Muellbauer (1984) discusses the uses of these data and for 1958-83 finds an insignificant role for CBI capacity utilization data in the explanation of British manufacturing productivity, given that labour utilization is measured through overtime hours variables.

The main criticisms of the gross capital stock data is of the fixed service life assumptions for the different types of capital assets and of the assumption of constant efficiency until the capital asset is retired. It seems implausible that scrapping would be independent of output and factor prices, taxes and demand conditions. In particular, as noted in the Introduction, one would expect a higher rate of scrapping to have taken place as a result of the systematically higher relative prices for fuel and raw materials from 1973*, and also probably because of the relatively depressed demand conditions that followed. Similarly, the 1979-80 collapse of British manufacturing output because of the dramatic increase in the real exchange rate, high real interest rates and fiscal contraction, is likely to have been accompanied by an increase in scrapping.

In principle, a vintage model of capital offers a way of modelling which vintages remain in use and which vintages are scrapped. Malcolmson and Prior (1979) and Malcolmson (1980) have developed an elegant model in which some of the parameters can be identified from aggregate data, without direct information on scrapping. However, the parameters of most relevance to measuring productivity growth are not identified.** This approach thus does not seem very helpful at present for measuring productivity growth.

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*Baily (1981) and Raasche and Tatom (1981) argue in favour of this hypothesis as a major explanation of the slowdown in productivity growth in U.S. manufacturing after 1973, though see Gordon (1981).

**Also, Mizon and Nickell (1983) who estimate other vintage models as well as this one have difficulty in obtaining sensible estimates of technical change for these.

Baily (1981) suggests that a stock market valuation may provide a more sensible measure of the capital stock but this could be sensitive to internationally driven interest rate changes. Scott (1976, 1981) goes further: he rejects conventional measures of the capital stock and argues instead for cumulated gross investment scaled by output.

In the face of these difficulties our approach is to allow for shifts in time trends for the periods in which, on a priori grounds, scrapping should have been higher. This is somewhat crude but we do not, at present, see a better alternative.

Turning now to the measurement of output, we treat biases in quality measurement as part of what is measured by the trend effect.* We focus on four other potential biases. The first of these, the gross output bias was mentioned in the introduction. The CSO approximates changes in value added by gross output changes for a disaggregated list of goods. These are weighted by value added weights from a quinquennial census of production. This is fine when value added and gross output change in the same proportion. But when prices of raw materials or of imported intermediate goods increase relatively to those of capital and labour, firms have an incentive to substitute. To the extent that substitution is in the pattern of output shifting in a less raw material or intermediates intensive direction, the CSO technique remains accurate since it rests on weighting by fixed weights. However, substitution for particular goods in favour of the input of labour and capital results in value added increasing faster than gross output. Bruno (1984) and Bruno and Sachs (1982) suggest that this bias is an important part of the explanation in the productivity growth slowdown for industrial countries from 1973.

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*Prais (1983) and Nicholson (1967) comment on the possibility of such biases but relatively little research exists for Britain in contrast to the large American literature on this subject.

Grubb (1984) challenges this pointing out that in countries which provide the correct value added statistics, these also reveal a slowdown.

We proxy the relative price of raw materials by PR, the (log) ratio of raw material prices purchased by British manufacturing to wholesale prices for domestic sales and the relative price of intermediate imports by PW the (log) ratio of foreign to domestic wholesale prices. Increases in PR and PW should be associated, because of the potential gross output bias, with downward biases in measured output increases and so these variables should have negative coefficients in an equation for measured output and should operate with a lag since substitution takes time.

The second bias to be considered operates in the opposite direction. About two thirds of manufactured output on the 1968 SIC definition which we use is based on current price figures deflated by wholesale price indices for home sales, though the proportion was lower before 1970 (see CSO (1976, 1983)). Something over a quarter of sales are traditionally exports though the share of exports tends to be higher in those industries where the data source is primarily sales.* The CSO deflates export sales by domestic wholesale prices indices since it regards the available export unit values as too unreliable, at least in the short run. When domestic price indices diverge from the unobserved export prices, what we call the 'domestic price index bias' in measured output results. The ratio of wholesale prices PW referred to above is an observable indicator of such a divergence. An increase in PW because, for example, of a fall in the value of Sterling, results in the measured price increase understating the true price increase and so the measured volume increase overstating the true increase. Much of this effect operates instantly and leads us to expect a positive coefficient on PW_t in the equation for measured output, but with part of the effect unwinding as export prices adjust.

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*See the tables on import penetration in the Monthly Digest of Statistics.

It is also likely that movements in true (unobserved) export prices relative to home prices are somewhat more attenuated than movements in PW but this will be reflected in the estimated coefficient.*

The third source of bias, which we call the 'list price bias' arises from another problem with the wholesale price indices for home sales (in 1983 renamed the 'producer price indices'). Although they are supposed to measure transactions prices, it is likely that they are partly based on list prices which, as Doug McWilliams of the CBI has argued to us, may differ from transactions prices because of discounting. A reduction in competitive pressure, reflected by an increase in PW, is likely to reduce discounts so that measured price increases understate true price increases and measured output increases overstate true ones. However, one would expect this effect to unwind in due course implying a positive coefficient on current or recent values of PW and negative coefficients on longer lags. One expects similar effects for PR, the relative price of raw materials, but for somewhat different reasons. It is likely that list prices respond more slowly than transactions prices to cost increases such as in raw materials (and imported intermediate goods). Thus an increase in PR is associated with measured prices understating the increase in true prices and so measured output increases overstating the true ones. Again, one expects a temporary effect only suggesting a similar lag structure for PR and giving another reason for a PW effect as a proxy for the relative prices of intermediates.

A Sterling depreciation raises PR and PW. The domestic price index and list price biases thus suggest an immediate overstatement in measured output followed in due course by a bias in the opposite direction as they unwind

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*For example, from 1978 to 1981, as Sterling appreciated the export unit value index fell about 11% relative to home prices while relative foreign wholesale prices fell by over twice that percentage.

and the gross output bias, if it exists, comes into play when substitution begins to take effect. If these arguments are correct, there could be substantial short run errors in measured output following the 1967 devaluation and over the 1970's and 1980's with their large fluctuations in real exchange rates.

Finally, let us consider the effects of price controls. Darby (1984) argues that price controls instituted in the U.S. in 1971 were widely evaded, for example, by firms claiming spurious quality improvements or simply relabelling goods. The increase in the official price indices thus understated the true increase, with the opposite for output. These biases reversed in 1974 as price controls were taken off and reported output and so productivity fell by more than the true figures. In Britain, price controls were introduced in April 1973, slightly relaxed in December 1974 and August 1976 and replaced in August 1977 by the much weaker Price Code. The Price Commission which operated these policies was finally abolished in 1979. The Price Commission's quarterly reports give figures which measure intervention both in number of cases and by the money value of sales effected. These make it possible to measure roughly the intensity of the controls. The hypothesis is that the more intense the controls, the greater the incentive of firms to evade them and the greater the bias in the official price indices and so in measured output. The Commission suggests that firms changed prices of each good by on the average two to three times per annum and this would suggest some lag in the effect.

3. Empirical Results

We begin by summarizing the notation and giving the range of variation for each of our variables, see Appendix for further details.

q_t = index of manufacturing output, 1980 = 100. Range: 65.3 in 1955.1, 115.3 in 1974.2.

ℓ_t = employment in manufacturing. Range: 5.347 million in 1983.4, 8.491 million in 1965.4.

K_t = gross capital stock for manufacturing at 1980 prices. Range: 88.4 billion in 1955.1, 211.1 billion in 1983.4.

$\bar{h}_t$ = normal hours = $0.4425 \times NH_t$ where NH_t = normal hours index. Range for NH_t: 100 in 1955.1, 88.6 in 1983.4 and 90.4 for 1968-79.

OH_t = (total number of overtime hours for operatives/$\bar{h}_t$ x total number of operatives)
Range: 0.0400 in 1958.3, 0.0876 in 1973.4.

PR_t = ℓn (wholesale price index for raw materials purchased by manufacturing)
$-\ell n$ (wholesale price index for home sales by manufacturing)
Range: -0.352 in 1972.2, 0.128 in 1974.1.

PRD_{t-3} = $PR_{t-3} - PR_{1969.2}$ from 1970.1 and zero before.

PW_t = ℓn (wholesale price index for foreign competitors)
$-\ell n$ (wholesale price index for home sales by manufacturing)
Range: -0.346 in 1981.1, 0.119 in 1976.4.

PWD_t = $PW_t - PW_{1970.1}$ before 1970.1 and zero after.

PC_t = $\dfrac{\text{(Price Commission intervention in £)}}{\text{(Wholesale price index for home sales by manufacturing)}}$

Range: 0 up to 1973.1 and from 1977.4, 7.74 in 1974.1.

EX1 = Excess of average January and February temperature over 1941-70 means in centigrade, defined for 1st quarter only. Range: -3.0 in 1963.1, 2.35 in 1957.1.

EX2 = Excess of preceding December temperature over 1941-70 mean in centigrade, defined for 1st quarter only. Range: -3.7 in 1982.1, 3.2 in 1974.1.

π = Proportion of firms operating below full capacity reported by CBI Industrial Trends Survey. Range: 0.38 in 1965.1, 0.84 in 1980.4.

PO = Proportion of employees who are operatives. Range: 0.700 in 1980.4, 0.801 in 1955.1.

Given the discussion in Section 2, and absorbing increases in paid holidays in the trend, we write the aggregate production function in the form

$$\ell n(q_t/K_t) = \text{const.} + \alpha\{\ell n(\bar{h}_t\ \ell_t/K_t) + u_t\} + \beta_{1j}\sum_{1}^{2} PC_{t-j} + \beta_{2j}\sum_{0}^{4} PW_{t-j}$$

$$+ \beta_{3j}\sum_{0}^{4} PR_{t-j} + \text{split time trends} + \text{seasonals} + \text{excess temperature}$$

$$\text{effects} + \text{special dummies} \qquad (4)$$

This imposes the restriction of constant returns to scale. The output measurement biases are measured by fairly general distributed lags in PR, PW and PC. The utilization rate u_t is defined as follows:

$$u_t = \text{const.} + OH_t - c_1\ OH_t^{-1} - c_2(NH_t - 90.4)\ OH_t^{-1} \qquad (5)$$

which generalizes (3) above by an unidentified constant and the interaction term with normal hours whose meaning we have discussed.* Substituting (5) into (4) gives an equation which can still be estimated by OLS. Muellbauer (1984) describes the search for a parsimonious form of this equation and the

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*Note that the interaction term is zero between 1968 and 1979.

results of a battery of tests for parameter stability, desirable residual properties, exogeneity of employment and overtime, and others to which this equation was subjected. Here, we concentrate on a description and interpretation of the equation and a discussion of its implications for productivity trends in British manufacturing. The estimated equation reads as follows, with absolute t-ratios in parentheses:

$$\ell n(q_t/K_t) = \underset{(8.3)}{-6.457} + \underset{(8.2)}{0.681}\,(\ell n(\ell_t/K_t) + \ell n\, NH_t + OH_t) - \underset{(10.2)}{0.01207}\, OH_t^{-1}$$

$$+ \underset{(8.2)}{0.05140}\, \frac{(NH_t - 90.4)}{100}\, OH_t^{-1} + \underset{(4.2)}{0.0050}\, PC_{t-2} + \underset{(3.6)}{0.1015}\, PWD_t$$

$$- \underset{(3.1)}{0.0668}\, PRD_{t-3} + \underset{(2.7)}{0.0591}\, \Delta_4\, PW_t + \underset{(3.7)}{0.0776}\, \Delta_3\, PR_t + \underset{(5.2)}{0.00451}\, t$$

$$+ \underset{(4.0)}{0.00172}\, TR59.4 - \underset{(8.2)}{0.00412}\, TR73.1 - \underset{(4.4)}{0.00788}\, TR79.3 + \underset{(6.0)}{0.01193}\, TR80.3$$

$$+ \underset{(2.4)}{0.0040}\, EX1_t + \underset{(2.7)}{0.0035}\, EX2_t$$

$$+ \text{terms in S1, S2, S3, S1TR and 8 (0, 1) dummies} \qquad (6)$$

s.e. = 0.007457, $\bar{R}^2$ = 0.9972, DW = 2.09, n = 112, df = 84

The estimated elasticity of output w.r.t. employment is 0.681 which is very reasonable, being quite near the average share over the period of labour in value added. The two terms in OH^{-1} are highly significant and have the anticipated signs. The interaction of OH^{-1} and normal hours indicates that a substantial downward adjustment needs to be made to measured overtime as a result of the reductions in normal hours in the late 1950's and in the 1960's to make the figures comparable with, say, mid-1950's overtime data.

We can now define our (log) utilization index u_t as

$$OH_t - [0.01207\, OH_t^{-1} - 0.05140\, \frac{(NH_t - 90.4)}{100}\, OH_t^{-1}]/0.681 \qquad (7)$$

The movement of u_t over time against that of log (output) is displayed in Chart 2 and gives a new* and interesting picture of the cyclical pattern of activity in British manufacturing. For example, despite the rapid shedding of labour, in 1981.1 the utilization of labour was 0.10 to 0.11 below the previous lows recorded in recessions in 1958.3, 1963.1 and 1971.3 and 0.21 below the peaks in 1969.4 and 1973.4. In a sense, this allows one to say that the 1980-81 recession was twice as deep as the next deepest recession experienced since 1955. The implications for conventional output per head were dramatic as the utilization rate recovered to a more normal level by the end of 1983 from the depths it had reached in 1980.

Now we turn to the price effects which proxy the measurement biases in output. The price control variable PC which measures the intensity of the Price Commission's intervention enters with a lag of 2 quarters, which in this context means an average lag of 5 months. The argument is that, in response to the Price Commission, firms took various steps such as altering the listed specifications of goods or reducing their quality or reducing discounts on list prices to by-pass price controls. These would have introduced a downward bias into the price indices used and so led to measured output being overstated.

Apart from PC_{t-2}, the price control effect is also represented by a 1977.1 dummy included in eq.(6). This reflects widespread fears in industry at the time that the changes in the operations of the Price Commission under discussion by the government would toughen up price controls. This would have given firms an extra incentive to side-step these controls. We estimate that the resulting price bias caused a temporary overstatement of output by 1.8%. In fact, partly no

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*We shall compare it below with the CBI capacity utilization data and with Bennett and Smith-Gavine's Percentage Utilization of Labour index. It is also comparable with Taylor's (1974) measure of labour hoarding. However, this is measured as the deviation of productivity from trends deduced from peak to peak interpolation. It would thus be tautological to use it to remove the cyclical component from productivity. See Leslie and Laing (1978) for a discussion of Taylor's measure.

doubt because of the very fears expressed, it became clear later in 1977 that the role of the Price Commission would be more limited and by the end of 1977 it had been reduced to little more than a public relations exercise.

PC_{t-2} reached a peak of 7.7 in 1974.3 which corresponds to an output bias of 3.9%. The Price Commission itself argues, see Price Commission Report for 1 March - 31 May 1977, p.14, that "at the peak, price control probably reduced prices by 3 or 4 percent compared with what they otherwise would have been". Given that the wholesale price index for output was 36% higher in 1974.4 than it had been in 1973.1 just before price controls began, the Price Commission's estimate is relatively modest, being based largely on observed profit margins. Our estimate supports this (subsequent) caution of the Price Commission in placing little weight on direct measures of the extent to which price increases were rolled back by the Commission. Our estimate of a 3.9% upward bias in output in 1974.3 corresponds to a somewhat larger downward bias in the wholesale price index given that only about 2/3 of the output estimate is based on deflation by wholesale prices. In that sense, we would argue that much of the apparent success attributed to the Price Commission at the time was a statistical illusion.

For the U.S., Darby (1982, 1984) argues that the price controls which were instituted in 1971.2 and removed in 1974.4 peaked in 1973.1. At the peak he estimates that output was overstated by 4.7% and that it is the elimination of this bias over 1973.1-74.4 rather than the contemporaneous oil price shock which explains the slowdown in U.S. productivity growth in 1973-4. For Britain in contrast, it is the introduction of price controls which explains why the productivity slowdown did not take place till later.

For British manufacturing there is a significant levels effect at a lag of 3 quarters for PR, the (log) price index of raw materials relative to that of output. Compared with 1970.1, PR peaked at a value of 0.39 higher in 1974.1 though by 1974.4 it was only 0.27 higher than in 1970.1. A sustained rise of 0.27 would, according to eq.(6), reduce measured output by 1.8%. This is the net effect of the raw materials price component of the gross output bias, the domestic price index bias and the list price bias. However, since the PR component of the latter two is likely to be small in the long run, we can interpret this effect as largely due to the gross output bias. Its lagged effect fits with the view that substitution takes time. Its small magnitude is consistent with the CSO's belief* and with the arguments of Grubb (1984) vis-a-vis Bruno (1984) and Bruno and Sachs (1982).

Before 1970 we could find no long term PR effect. This should not be too surprising in view of the small and relatively predictable pattern of movement in PR before about 1972. PR followed a small procyclical movement around a gently declining trend until 1972.2, with an interruption for the 1967 devaluation.

The rate of change effect over 3 quarters $\Delta_3 PR_t$, is consistent with the hypothesis of a list price bias and a domestic price index bias though the latter is more likely to be picked up by the PW variables. These have the predicted positive coefficient on the rate of change in the form $\Delta_4 PW_t$. The positive coefficient on PW_t pre-1970 represents the combined long run effect of the gross output, domestic price index and list price bias. The first one should have a small negative effect and the long run list price bias is probably small. So the pre-1970 coefficient of 0.1015 is likely to reflect largely the domestic price index bias. Note that the short run effect of this was even larger but before 1970 37% of it was eliminated within the year, presumably as the gap between domestic and export prices created by, for example, the 1967 devaluation was narrowed again by cost pressures on export prices. Post 1970 the point estimate of the coefficient on PW_t is

*Private correspondence in 1984.

positive but not significantly different from zero. This suggests that we can accept the hypothesis that post-1970 exchange rate changes and shifts in relative foreign and domestic inflation rates have had only transient effects on the relative movements of export and domestic prices in British manufacturing.

Chart 2 plots the output bias, which is the combined effect of these elements we have discussed, against output and utilization. Though much less important than utilization, the output bias has a significance which is not negligible, especially at times when there were sharp changes in the real exchange rate.

To take the recent example of the depreciation of Sterling from November 1982 to April 1983, followed by some rebound, Table 1 shows the CSO's index for output adjacent to our correction of it. Our correction is obtained by

Table 1: Output and bias corrected output for 1982.3-1983.4

	CSO output index (1980 = 100)	Our corrected index (1980 = 100)
1982.3	93.2	93.1
1982.4	92.5	92.0
1983.1	94.4	93.0
1983.2	94.1	93.3
1983.3	96.0	95.3
1983.4	97.1	96.4

subtracting from official output (in logs) the estimated bias term implied by our equation. Conditional on the specification of the equation this has a standard error of only about 0.06% for this period, implying a 95% confidence band of ±0.1 around our figures, given the CSO's. Table 1 indicates that relative to the average for 1980, the CSO's 1982.3 figure is only very slightly biased but the figures for 1982.4-83.4 are all significantly biased upwards. In terms of quarter to quarter changes, we see a substantially smaller recovery of output in 1983.1 but the recovery continuing into the second quarter in contrast to the CSO's estimate of an actual reduction in output. Indeed our corrected index is more in line with other information. The CBI Industrial Trends Survey suggests fairly smooth increases in output in 1983 while hours of work did not fall in 1983.2 contrary to what the official output index might have led one to expect. As it happens, there is little diagreement about the year on year rate of growth from 1982.4-83.4, but as Table 1 indicates, quite sharp disagreements about particular quarters.

Let us turn to the trend effects. As well as the standard trend these include linear splines of the form $\Sigma \beta_i \; TRJ_i$, where TRJ is defined above. Combined, these yield a continuous line made up of straight line segments which change slope at observations J_1, J_2 etc. Up to 1959.3 the estimated trend effect is 0.00451 per quarter, ie. 1.8% per annum. Such a trend effect can be interpreted as a change in technology or working practices, a trending measurement error in the quality of output or the inputs, a change in the prevalence of shift work and in holiday time and as some combination of aggregation biases.

From 1959.4 the effect rises to 2.5% p.a. but from 1973.1 drops sharply to 0.8% p.a. This can be interpreted as economic scrapping because of the altered structure of relative prices resulting from the first oil and associated raw materials price shock. One would expect such scrapping to be relatively long drawn out since there would be a general tendency for capital to be scrapped younger after 1973 except for those post-1973 vintages designed to be more appropriate to the prevailing relative prices. It is plausible that there may also have been increased scrapping because of the relative slackness of demand conditions in the years that followed.

Our estimates further suggest that for 1979.3-80.2, the trend effect fell to -2.3% p.a. The most obvious interpretation is economic scrapping caused by the sharpest collapse of manufacturing industry since 1920-21. Output bottomed out in 1980.3 and the net trend effect from 1980.3 onwards is 2.5% p.a., the same as it had been throughout the 1960's and early 1970's. On this interpretation, as far as productivity trends are concerned, the seven years 1973-80 were an aberration in which, because of the prevailing economic conditions, scrapping or loss of productivity of the capital stock took place which was not reflected in the official gross capital stock figures.

If this interpretation is valid, the change in the CSO's service lives assumptions introduced in the 1983 National Income and Expenditure Blue Book is rather implausible. To quote, p.114, "The average service lives assumed for manufacturing plant (other than that in the motor vehicle industry) have been reduced by installments from just over 30 years for assets installed before 1950 to about 23 years for assets installed from 1970 onwards". An analogous change was made for manufacturing buildings. This makes the assumed service life hinge on the date of installation rather than on the economic conditions under which capital is used, the latter being what our analysis would suggest. If our extreme assumption is right and the 1973-80 slowdown in utilization corrected productivity growth is entirely attributable to a cumulative measurement error in the capital stock which is finally about 35%*, it would be an argument for a major CSO investment in improved capital stock data. However, this is not to underestimate the practical and conceptual** problems of a survey of retirement decisions for capital assets.

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*The cumulative effect in 1980.2 of TR73.1 and TR79.3 on log output is 0.139 scaled by an elasticity of output w.r.t. capital of 0.319 this gives 0.436. In conventional percentage terms this is 35% of the 1973.1 capital stock.

**Scott's (1976, 1981) discussion of some of the conceptual difficulties in defining the capital stock is relevant to them.

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In the remainder of the equation, there are seasonal effects and an allowance for unusual weather conditions affecting output in the first quarter through the excess temperature variables EX1 and EX2. Finally, let us turn to the (0,1) dummies for strikes and other unusual events. With the exception of the 1977.1 dummy already discussed, these are all negative. Pre-1970 there are two dummies. One takes the value one in 1956.4, 1959.3 and 1962.1 and reduces output by 1.4% in those quarters. 1956.4 saw the Suez crisis and petrol and diesel rationing and 1959.3 a strike in the motor industry and a 3½ month steel strike in the U.S. which caused a shortage of sheet steel. 1962.1 was a record quarter for working days lost because of strikes. The other dummy has a -2.4% effect in 1963.2 and probably reflects delays in the completion of various investment projects because of the severe weather experienced in the first quarter. Post 1970, there are effects of -2.2% in 1970.1 and -2.1% in 1970.2, -2.0% in 1972.1 and -2.1% in 1974.1. The 1970.1 and 2 dummies probably represent the effects of strikes in the motor, shipbuilding and steel industries. The 1972.1 dummy reflects the miners' strike and the 1974.1 dummy the miners' strike and the three-day-week imposed on industry to conserve energy. Of these disputes, the one in 1974.1 undoubtedly resulted in the largest output loss. The coefficients on the dummies reflect the effect on output once any effect on overtime and employment is allowed for and this explains why the 1974.1 coefficient is not the largest.

As usual, one could be concerned about the degree of ex-post rationalization in the inclusion of certain dummies in preference to others. The 1972.1 and 1974.1 dummies are unarguable. The evidence in Muellbauer (1984) shows that omitting the remainder has only slight effects on the remaining parameter estimates, though, of course, the equation standard error deteriorates.

Next, we compare our cyclical utilization measure with two alternatives. The CBI Industrial Trends Survey is currently the best known source for an indicator of cyclical utilization. Firms in the survey are asked whether their current level of output is "below a satisfactory or full rate of operation" and the data series on the proportion answering "yes" goes back to 1958. For 1958-72, the survey was triannual and quarterly since 1972, though the survey dates are not centred at midquarter. Our quarterly series on π, the proportion answering "yes", is an interpolation centred at mid quarter.

A capacity utilization indicator can be constructed from π by the following argument. Suppose that firms have a common standard of what a satisfactory or full rate of operation means. It might, for example, be 90% of the maximum output each could conceivably produce. Define the utilization rate of the ith firm, $u_{ci} = \ell n\ q_i - \ell n\ q_i(\max)$. Then the threshold corresponding to output at 90% of the maximum is $u_{ci} = \ell n\ 0.9$. Given appropriate assumptions on the distribution of u_{ci} over firms weighted by size, $\pi = F\ (\ell n\ 0.9)$ where $F(\ )$ is the distribution function of u_{ci}. $F(\ )$ depends on the mean of u_{ci}. Given the distributional assumptions made in Muellbauer (1984), the mean of u_{ci},

$$u_c = -\text{const.}\ (\pi/1-\pi)^{\theta}\ . \qquad (8)$$

By omitting the overtime variables from the production function and taking u_c to be the only utilization variable, grid search suggested

$$u_c = -0.11\ (\pi/1-\pi)^{0.4} \qquad (9)$$

Incidentally, this turns out to imply that the threshold level at which firms define 'full capacity' is 91% of the maximum output level. Although the parameter estimates are plausible, this regression fitted for 1958.3-83.4 has a standard error of 0.0113 and a Durbin-Watson statistic of 1.42 and so is much less satisfactory than eq.(6).

In Chart 3 we plot 0.681u, which measured the impact of labour utilization on output, against u_c as defined in (9). The overall cyclical pattern is remarkably similar though the CBI capacity utilization index u_c lags slightly behind our labour utilization index u. The tests reported in Muellbauer (1984) suggest that u_c does not contain useful information additional to u but it is reassuring that the cyclical patterns are so similar.

A measure of utilization which is explicitly one of labour utilization is that produced since 1971.2 by Bennett and Smith-Gavine (1984). They regularly publish both a utilization index which they call PUL (Percentage Utilization of Labour) and a utilization corrected productivity measure which they call Technological Productivity. Their data is based on a continuous survey of plants in which production management provides work-study based information on the intensity of utilization of operatives. They define labour input as PUL x total number of operative hours, the latter being the Department of Employment's figure. Their Technological Productivity is then output divided by this definition of labour input.

In contrast we define labour input as

$$\text{total employment} \times \text{normal hours} \times \exp(u) \qquad (10)$$

To make our results as comparable as possible with theirs, we re-estimated our equation scaling total employment by the (quarterly interpolated) proportion of operatives in manufacturing. This gave a utilization rate u_o defined as

$$u_o = OH - 0.02132\ OH^{-1} + 0.07891\ \frac{(NH - 90.4)}{100}\ OH^{-1} \qquad (11)$$

We can now define $\hat{u}_o$ which is a transformation of Bennet and Smith-Gavine's concept into our framework as follows:

$$\hat{u}_o = \ell n\ PUL + \ell n(\text{average hours per operative}) - \ell n\ \bar{h} \qquad (12)$$

Chart 4 plots u_o based on our approach against $\hat{u}_o$ based on their approach. The graphs are broadly similar. The main differences are that theirs is below ours for 1976.2-80.2 but above ours from 1981.2. They would therefore attribute more of the slowdown in productivity growth in the 1970's to lower utilization and be somewhat more pessimistic about the productvity gains available beyond 1983 from higher utilization. Re-estimating for 1971.2-83.4 the aggregate production function with the number of operatives defining employment and the overtime variables replaced by $\hat{u}_o$ which is the transformation of Smith-Gavine's concept defined in (12), gives a coefficient on $\hat{u}_o$ similar to the employment elasticity of output but with the equation standard error 36% higher than in our equation which uses the overtime data.*

Finally, we turn to the key underlying question of how to construct a labour utilization corrected measure of productivity. Labour productivity in logs is conventionally defined as $\ell n\ q - \ell n$(labour input). This would therefore suggest taking $\ell n\ q - \ell n$(utilization corrected labour input) as the appropriate definition on the lines of Bennett and Smith-Gavine's 'Technological Productivity'.

However, given our production function estimates which yield an elasticity of output w.r.t. employment of 0.681, we would argue that a somewhat more appropriate definition of utilization corrected labour productivity in our context is

$$\ell n\ q - 0.681\ (\ell n\ \ell + \ell n\ NH + u) \tag{13}$$

An even more representative picture of underlying productivity trends is obtained when we correct for the output measurement bias, the seasonal effects, the excess temperature variables and the (0,1) dummies whose effects we have

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* However, this comparison is biased against $\hat{u}_o$ since the parsimonious specification of the other variables in our equation has, in a sense, been selected to make the overtime data perform well.

estimated in our production function, eq.(6). This concept plotted for 1955-83 is shown in Chart 5 in comparison with conventional (log) output per head. In what follows, we refer to this concept as 'corrected productivity'.*

From the long run perspective, the similarity between the two is notable. But it is remarkable how for periods as long as 3 or 4 years, output per head can give such a distorted picture of the long run trends. Depending upon whether a period of recovery such as 1966.4-68.1, 1971.4-73.1 or 1980.4-83.4 is included, output per head can experience dramatic growth. Yet, as Chart 5 suggests, nothing unusual was happening to underlying productivity trends. Nowhere is this more pronounced than in 1980.4-1983.4 when output per head grew 7.2% p.a. as compared with 3.2% in the period before the first oil shock, 1955.1-73.1. In contrast, corrected productivity grew 2.6% in 1980.4-83.4 and 3.4% in 1955.1-73.1.

We conclude by offering the reader a little choice in forecasting underlying productivity trends in British manufacturing. As far as eq.(6) goes, the key parameters are the shifting trends whose cumulative effect is what matters. 1980.3 was the last date at which a shift in the trend slope was permitted in eq.(6). To investigate the possibility of later shifts, we ran 5 versions of eq.(6) varying the date of a later shift from 1982.1 to 1983.1. Table 2 shows t-ratios for each of the respective TRJ coefficients and gives the cumulative trend coefficient before and after the shift date. Multiplying this by 4 gives the annualized percentage rate of change of whatever it is in trend output that measured capital, employment, labour utilization and output biases cannot explain.

Table 2 thus gives the choice of an annual rate of change of this productivity residual ranging from 2.5% to 3.5% and so varying degrees of optimism regarding future productivity trends. As the shift date J moves

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*The trend pattern of corrected productivity, apart from random shocks, is the same as the combined effect of the trends estimated in (6) and of measured capital.

Table 2: a menu of trend shifts additional to those in eq.(6)

J	TRJ coeff.	coeff. s.e.	cumulative trend before J	cumulative trend from J
none			0.00616	0.00616
1982.1	0.00146	0.00214	0.00476	0.00622
1982.2	0.00214	0.00215	0.00428	0.00642
1982.3	0.00315	0.00213	0.00369	0.00684
1982.4	0.00398	0.00224	0.00353	0.00751
1983.1	0.00507	0.00254	0.00360	0.00867

forward in time, TRJ becomes closer to being just a dummy variable for the latter part of 1983 and obviously a more and more dubious guide to the future.

4. Conclusions

This paper has been concerned with three measurement problems in the main: the measurement of utilization, output and capital. For the first two we were able to find economic variables to solve the measurement problems that we considered. Measurement problems in capital are in their nature more trend like and, in the absence of appropriate economic indicators, we used shifting time trends to proxy capital measurement biases. Given the various other factors that trend shifts could be reflecting, identification is necessarily more speculative here. With these techniques, we were able to construct a measure of productivity growth corrected for the very substantial variations that took place in labour utilization and for relatively less important measurement biases in output. In the short run this gives a very different picture from conventional growth in output per head, and moreover, one that is much more informative about underlying trends.

Our utilization measure is based on overtime hours relative to normal hours. We argue that this is a good indicator of above normal utilization levels and that, since most workers receive payment for a standard week even when underutilized, no corresponding direct measure of underutilization exists. However, a statistical aggregation argument suggests that the average degree of utilization can be deduced as a non-linear function of the proportionate overtime data. Comparing our measure with a capacity utilization index derived from the CBI Industrial Trends survey available from 1958.3 and with Bennett and Smith-Gavine's Percentage Utilization of Labour index available from 1971.2 reveals a broadly similar cyclical pattern. However, on our evidence, our measure produces more satisfactory econometric results in modelling output.

Corrected productivity growth as we define it measures the growth in bias corrected output after the contribution of changes in labour utilization, employment, seasonal effects, unusual winter weather and special events such as strikes have been removed. As we have explained, it can reflect a number of factors: the contribution of capital accumulation to output, changes in technology and work practices, omitted quality changes in output and the labour force, changes in the number of working weeks caused by increased paid holidays, any trends in the use of multiple shift working and any biases that come from aggregating micro production functions into an aggregate relationship. All of these, of course, are just as much part of the growth in conventional output per head.

Our corrected productivity growth measure throws new light on the two major controversies regarding British productivity growth: the apparent slowdown beginning around the time of the first oil shock and the dramatic apparent increase which followed the 1979-80 crisis in British manufacturing. We find both, in a sense, genuine. We estimate that, for 1955.1-73.1, corrected productivity grew at the rate of 3.4% p.a. while for 1973.1-79.3 it slowed to 1.4% p.a. Since our measure is corrected for cyclically varying labour utilization, we can dismiss the hypothesis that the slowdown was merely a symptom of the extended recession that followed the first oil shock.

Neither can we account for it merely in terms of the slower growth that took place in the recorded gross capital stock. This grew, we estimate, at 3.7% p.a. for 1955.1-73.1 and at 2.5% p.a. for 1973.1-79.3. Given an elasticity of output w.r.t. capital of 0.32, this explains only 0.4 of the 2% slowdown. Somewhat more rapid growth of paid holidays, on which there are some rough data, accounts only for 0.1% p.a. of the slowdown. Nor, as also argued by Grubb (1984), can it be explained significantly by the Bruno (1984) and Bruno and Sachs (1982) hypothesis of gross output bias. Over 1973.1-79.3 this explains a slowdown of only 0.3% p.a.

The fall can be interpreted in a number of ways: we have listed the several influences which, in principle, could be reflected in a productivity growth measure. However, we suspect that the main element was scrapping (or other unrecorded loss of productivity of capital) not measured in the official gross capital stock figures. As we have noted, the latter assume service lives for each type of asset to be independent of economic conditions and no decline in the efficiency of service flows as the asset ages. If we interpret the reduced size of the estimated trend in eq.(6) in these terms, we find an accumulated effect of 0.107 over 1973.1-79.3 in terms of log output. This translates into 0.336 of log capital, ie. about 27% of the 1973.1 capital stock after making an allowance for increased paid holidays.

One alternative hypothesis is a more sociological one. After the first oil shock, the capacity of industrial countries to produce income fell. The main causes were the shift in the terms of trade and the recession induced by a temporary fall in world liquidity in turn caused by the shift in international purchasing power and not compensated for by macroeconomic policies. The hypothesis is that trade unions, having achieved the highest levels of market and political power hitherto, responded by intensifying restrictive practices in order to maintain real wage growth and employment in this less friendly environment. This then reduced productivity growth. There could well be something in this: we have evidence neither for nor against such an unfavourable new trend in working practices. However, proponents of this view have to explain the speed up in productivity growth in an environment of the 1980's which was even more hostile to trade unions. Perhaps this can be done with reference to the loss of trade union power both in market and political spheres under the Thatcher administration.

For 1979.3-80.3 we estimate that corrected productivity growth was slightly negative at -0.3%. We would interpret this largely as the effect of unrecorded scrapping. Relative to pre 1973 trends, the estimated trend effect for 1979.3-80.3 is 0.048 lower which would be equivalent to 14% of the 1979.3 capital stock. Unrecorded scrapping of this magnitude is not implausible since the drop in output was even larger. On the other hand, if the shake-out raised the productivity average of the surviving plants, unrecorded scrapping would have needed to be higher still to produce a net effect of this magnitude.

Finally, for 1980.3-83.4 we estimate that corrected productivity growth was 2.9% p.a. which is still significantly below the 1955.1-73.1 rate of 3.4% p.a. However, we have to bear in mind that at the low rates of investment which prevailed, the recorded capital stock grew at only 0.9% p.a. in 1980.3-83.4 compared with 3.7% p.a. for 1955.1-73.1. Productivity growth correcting also for recorded capital growth thus looks 0.4% p.a. higher over 1980.3-83.4 than over the pre-1973 period. As it happens, the estimated trend effect for 1980.3-83.4 is the same as over 1959.3-73.1, exceeding slightly the effect in the longer pre-1973 period. One could argue, therefore, that the post 1980.3 situation represents merely a reversion to the kinds of productivity growth rates experienced in the 1960's and early 1970's.

It is hard to put a clean-cut interpretation on these figures, however. Output did not bottom out until 1981.1 so it may be that in the first few quarters of the 1980.3-83.4 period some unrecorded scrapping was still proceeding while the shake-out may have been still weeding out plants of below average productivity. The subsequent return to pre-1973 productivity growth levels can be interpreted by the termination of the process of unrecorded scrapping that began in 1973. There may also be something in the more sociological explanations discussed above and in the Introduction. Finally, the microchip revolution and the spread of computer controlled machine tools may be having an impact. Whatever the true balance of factors, there are signs in the estimates that if rates of investment recovered to pre-1973 levels, corrected productivity growth could exceed pre-1973 levels. For example, corrected productivity grew 4.20% over 1982.4-83.4. However, not much statistical significance can be attributed to these signs.

One possible explanation of unusually rapid productivity growth in 1983 is the following. Given previously high scrapping levels and a significant recovery in utilization levels, it may be that unobserved scrapping during 1983 was substantially below the levels implied in the CSO's fixed asset life assumptions. In this case the true capital stock would have grown faster than the measured capital stock, thus implying a short term acceleration in the growth of the unexplained productivity residual in 1983.

Whatever the truth, it is clear that the image which Chart 1 presents of productivity growth rocketing in 1981 and beginning to rocket upwards again in 1983.1 is rather misleading. Thus, the spectacular increase of 0.074 in log output per head between 1981.1 and 1981.4 was accompanied by a no less spectacular increase in (log) labour utilization of 0.099. In 1983.1 compared with the previous quarter log output per head was 0.042 up. Once the effects of high utilization, the abnormally large upward bias in output caused by the sudden drop in the real exchange rate and the unusually favourable weather are removed, corrected productivity growth was, we estimate, only 1.4% in this quarter.

As far as those output biases that we have considered go, our findings suggest only a small gross output bias. But although the price control bias does not affect the 1973.1-79.3 comparison, at its peak in 1974.3 we conclude that output was overestimated by 3.9%. The 'domestic price index' and 'list price' biases also have little significance in the long run. But, as we have seen, they can quite significantly distort the short run picture both of productivity growth and the level of macroeconomic activity implied by the official statistics for manufacturing output.

Data Appendix

This gives sources and further details additional to the information on p.14-15 above. The following abbreviations for sources will be used: ET is Economic Trends, HABLS is the Historical Abstract of British Labour Statistics, DE is the Department of Employment and DEG the DE Gazette.

Manufacturing is defined according to the 1968 SIC. The main differences in the 1980 SIC are that energy processing and quarries have been removed and photographic processing added.

q_t = index of manufacturing output at constant factor prices, seasonally adjusted and stock adjusted from 1970. The base is 1980. Up to 1978 the source is ET. From 1978 the index comes from unpublished CSO estimates in 1980 prices for the 1968 SIC definition which was superceded in September 1983 by the 1980 SIC. The series is made up of 5 year segments each with constant price weights and up to 1978 chained by the CSO itself. Seasonally unadjusted data would have been preferred but the only series available was not on a per working day basis unlike the seasonally adjusted series. Differences in the quarterly incidence of public holidays and the pattern of week-ends tend to be irregular and not well modelled by seasonal dummies so that a per working day basis is desirable.

ℓ_t = employment in manufacturing, an average of 3 monthly figures. This refers to all employees, part time and full time. Before June 1962, DEG, March 1975 gives benchmark estimates for June 1959, 1960 and 1961. Between these dates, the monthly data from HABLS were adjusted by linearly interpolated adjustment factors and the June 1959 factor used for data before that date. From June 1962, a continuous series was provided by DE. For October 1983 onwards, only data for the

1980 SIC definition of manufacturing are available. 1983.4 is thus spliced onto the series using a 1983.3 splicing factor. From October 1981 the (optional) estimates of additional employment given by DEG are included in the data.

K_t = gross capital stock in manufacturing at 1980 prices including an allowance for assets leased by the manufacturing sector. Assets cover buildings, plant and machinery and vehicles.

The 1983 National Income and Expenditure Blue Book gives for the first time a gross capital stock series including leased assets. It also incorporates new assumptions about service lives but defines manufacturing by the 1980 SIC. The main difference from the 1968 SIC is the exclusion of energy processing. Data on gross investment for manufacturing on the 1980 SIC basis and estimates for the energy processing sector were helpfully provided by Bob Armitage of the CSO and Paul Mattock of the Department of Trade and Industry's Business Statistics Office. We began by computing annual retirements $R_T = I_T - \Delta K_T$ where I_T is annual gross investment and K_T is the Blue Book gross capital stock figure at year end. Quarterly interpolation of $\frac{1}{4} R_T$ then gave a quarterly retirement figure. We computed end of quarter capital stock series from $K_t = K_{t-1} + I_t$ (not leased) + I_t (leased) - R_t. Before 1975 no data on leased investment are available but since it is thought leasing was negligible pre-1967, we interpolated the 1975 fraction of leased investment back to 1967 so as to give zero in 1967. This then gave an estimated series for I_t (leased). No information on assets leased by the energy processing sector was available and it was assumed that this element was negligible. In the formulae above, K, R and I (not leased) thus refer to the total of manufacturing on the 1980 SIC basis and the energy processing sector. I (leased) refers to 1980 SIC manufacturing only.

$\bar{h}_t$ = normal hours for manual workers in manufacturing as given by national collective agreements. Source: HABLS, DEG.

$$OH_t = \frac{\text{total weekly overtime hours}}{\text{total number of operatives x normal hours}} .$$

Source: HABLS, DEG. This is an average of 3 observations per quarter, referring to a week at each mid-month from June 1961. Earlier figures refer to one mid quarter week in each quarter. The breaks in the series in 1961, 1966, 1969 and 1974 were chained appropriately. The 1974 break is probably the most serious. From June 1974 the data coverage includes ship-building and ship repairing and the overtime of maintenance workers' while the earlier data did not. The hypothesis of parameter shift in June 1974, however, could be rejected.

$$PR_t = \ln \left(\frac{\text{wholesale price index for raw materials and fuel purchased by manuf.}}{\text{wholesale price index for home sales of manufacturing}}\right)$$

Source: ET from 1957.1. Earlier figures are a quarterly average of monthly data from the Monthly Digest of Statistics.

$$PW_t = \ln \left(\frac{\text{wholesale price index for foreign competitors}}{\text{wholesale price index for home sales of manufacturing}}\right)$$

Source: ET relative wholesale price index measure of competitiveness from 1963.1. Pre-1963, a wholesale price index for manufactures was constructed using export shares as weights from data on the U.S., Japan, Germany, France and Italy from the UN Monthly Bulletin of Statistics and converted into Sterling. This index, divided by the wholesale price index for home sales of British manufacturing, was spliced to the competitiveness index at 1963.1.

PC_t = $\dfrac{\text{Price Commission intervention in £ terms}}{\text{wholesale price index for home sales of manufacturing}}$

Source: Price Commission Quarterly Report for the period 1 June - 31 July 1977, p.6.

EX1, EX2 = excess temperature variables. Source: Annual Abstract of Statistics and for 1983, Monthly Digest of Statistics.

π = proportion of firms below full capacity reported by the CBI Industrial Trends Survey. For 1958 to 1971 the data refer to February, June, October. For the 1st quarter, we take the February observation; for the 2nd quarter, $\frac{1}{4}$ February + $\frac{3}{4}$ June; for the 3rd quarter, $\frac{1}{2}$ June + $\frac{1}{2}$ October, for the 4th quarter, $\frac{3}{4}$ October + $\frac{1}{4}$ February. From 1982, the data refer to January, April, July, October. Thus a centred 1st quarter figure is $\frac{2}{3}$ January + $\frac{1}{3}$ April and analogously for the remaining quarters. The missing observation at February 1971 was interpolated from October 1970 and June 1971 using overtime hours data.

ww = ℓn (52 - 1.6 - average weeks annual holiday entitlement), linear quarterly interpolation. Holiday entitlements data are annual from HABLS and DEG and refer to all manual workers in national collective agreements or under Wages Councils orders. The published tables give the percentage of manual workers with basic holidays of 2 weeks, 2-3 weeks, 3-4 weeks, etc. The mid-point of each range was used to aggregate these.

PO = proportion of employees who are operatives = 1 - proportion of administrative, technical and clerical staff. The data refer to October up to 1962, April and October for 1963-74, October only to 1980, and September only from 1981. A linear quarterly interpolation was used.

Source: HABLS, DEG.

Average hours per operative (used in eq.(12) only). The continuous, seasonally adjusted series in ET Annual Supplement for 1984 was used, being the only consistent series available, although it corresponds to the 1980 SIC definition of manufacturing. However, it appears that the various changes made in 1981 to the method of construction were more serious than the change in SIC definition.

Chart 2: output, output bias and utilization, 1955.1-83.4

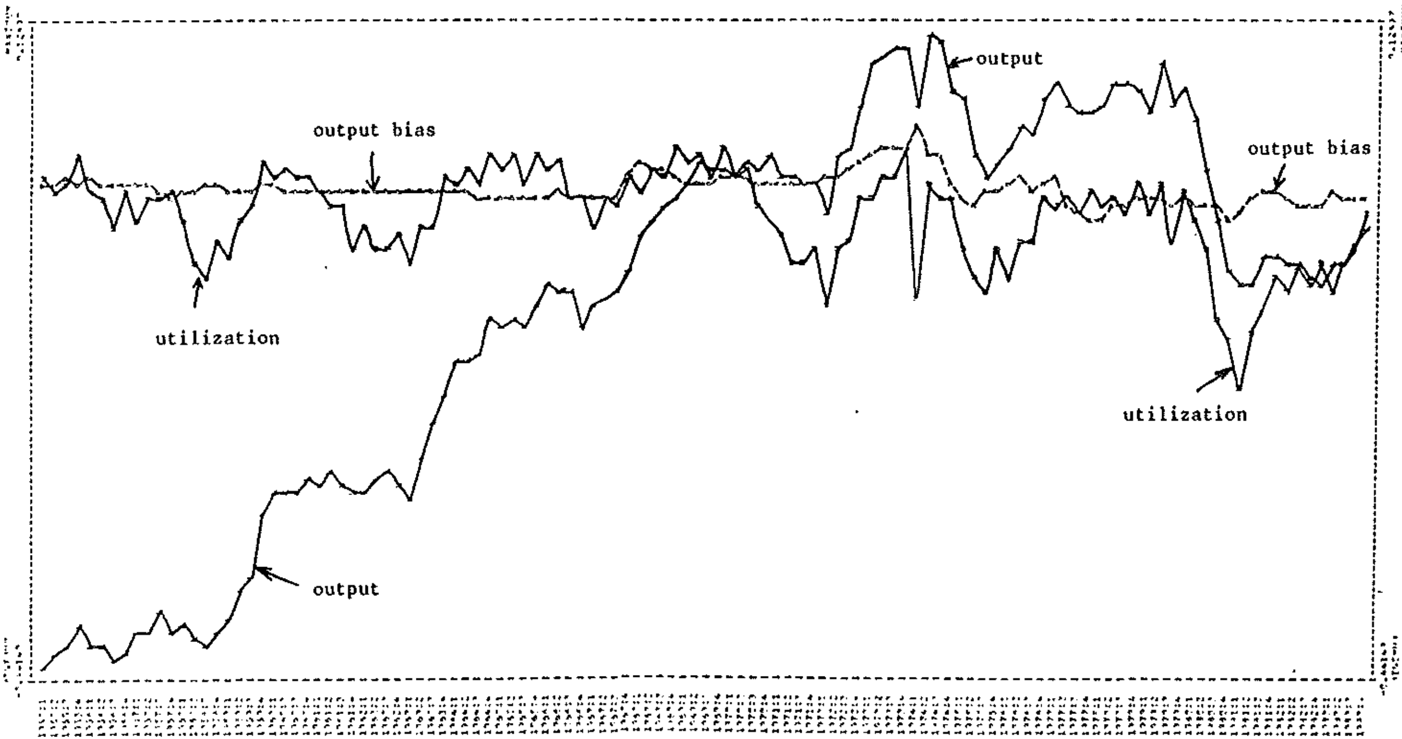

Chart 3: utilization and capacity utilization derived from CBI, 1958.3-83.4

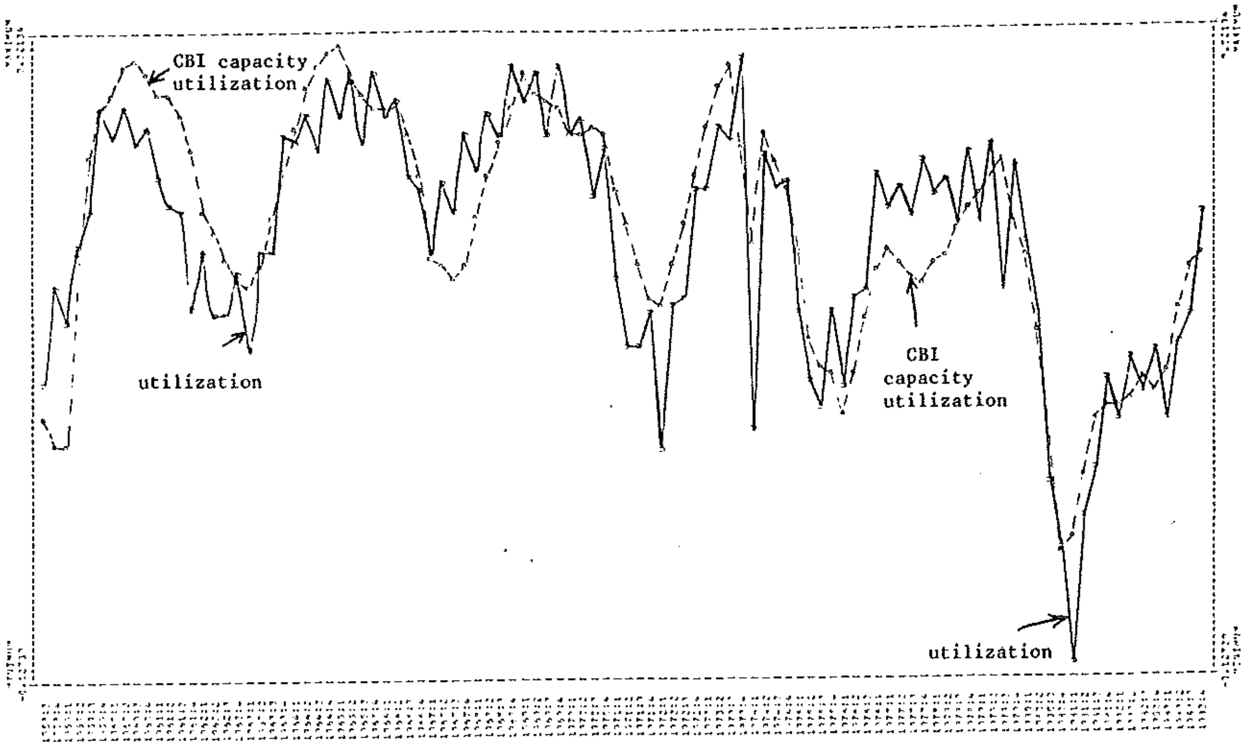

Chart 4: u_o and $\hat{u}_o$ (based on Bennett and Smith-Gavine's PUL), 1971.2-83.4

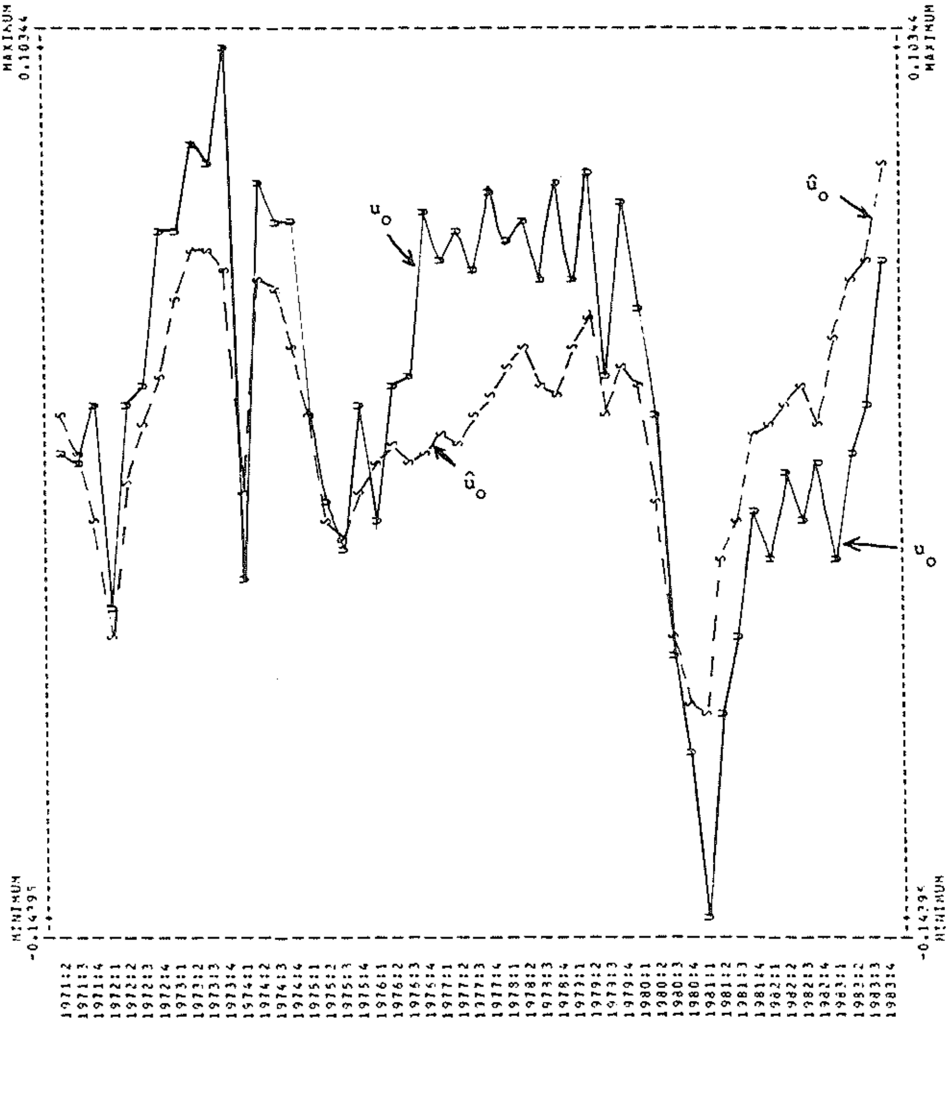

Chart 5: output per head vs. utilization and bias corrected productivity, 1955.1-83.4