Productivity trends

The 1980s have witnessed significant changes in labour productivity in the United Kingdom compared with the previous decade. These changes are most marked in figures for output per head, especially in the manufacturing sector where labour productivity has grown by 4.4% per annum on average in the 1980s compared with 2.3% for the 1970s. For the aggregate economy, the comparable figures were 2.2% and 1.8%. A note in the August 1987 Bulletin *(page 336) discussed these changes and made estimates of the likely changes in the underlying trend in productivity which they implied. In the light of the further strong growth in output which has occurred since, this note reappraises the evidence for an improved trend in productivity, by updating two previous studies on this subject. If a significant change in productivity performance has occurred, this is an important element in an improvement in the supply side of the economy with, in turn, implications for trade performance and inflation. The first section of this note briefly discusses some factors which may produce productivity improvements, while the second provides some evidence of a productivity improvement and its likely scale. The illustrations concentrate upon the manufacturing sector.*

Explanations of productivity change

Productivity improvements may be defined in broad terms as output increases which cannot be attributed to changes in fully utilised inputs. But there are a number of less formal measures which are used in the discussion about productivity. Output per head, and output per man hour (allowing for variations in average hours worked) are the two most common. Trends in these series are often taken to be synonymous with the (labour) productivity trend. This is rather too simple, however, and two alternative measures are discussed in the next section which attempt to identify underlying trends in productivity, once allowances for the role of other contributory factors and changes in utilisation rates have been made.

A number of arguments have been advanced which suggest reasons why productivity may have risen in the 1980s. One such argument is that changes in labour relations which have occurred since 1979 have an important bearing upon labour productivity. A version of this argument which has achieved some attention recently is one which emphasises the effects of unions upon productivity. This is emphasised by Metcalf[1] who summarises evidence that closed shops or workplaces with high union density have lower labour productivity than non-union workplaces. However, the effects of unions on productivity may go either way. For example, productivity may be reduced by restrictive practices or industrial action; on the other hand, productivity may be higher if there is a union effect on relative wages (a differential in favour of unionised workers) which induces highly unionised firms to substitute capital for labour. But the evidence surveyed by Metcalf at the firm and industry level seems to show that unionisation is associated with lower labour productivity. This evidence is cross-section, so the findings are not immediately relevant to the problem of explaining why labour productivity has appeared to improve over time. But many closed-shop arrangements have been discontinued in the 1980s. Furthermore, legislation during the 1980s has weakened closed-shop arrangements, so it may be that these could have had some effect, tending to improve the trend in labour productivity.

The 'batting average' argument suggests that the improvement in productivity was due to shedding of below-average workers and plant. This argument rests upon the view that the recession closed low-productivity plants, thus raising the average productivity of the survivors, implying a once-for-all effect. Oulton,[2] in reviewing evidence for the hypothesis for the manufacturing sector, notes that large plants were most affected by the recession, but there is little evidence to suggest that these were low-productivity plants. The argument that plant closures raised the average level of productivity thus does not appear to be supported by this evidence.

A third argument centres on the role of investment. A number of economists have emphasised that the productivity slowdown in the 1970s and its later improvement can be explained by investment behaviour. The most plausible model in this context is the so-called 'vintage' capital model, according to which new investment is the source of technological improvement because new technology is actually embodied in new equipment and structures. In the most extreme version of

(1) Metcalf, D. 'Trade unions and economic performance: the British evidence'. Centre for Labour Economics, London School of Economics. Discussion Paper No 320, 1980.
(2) Oulton, N. 'Plant closures and the productivity miracle in manufacturing'. *National Institute Economic Review* No 121, August 1987.

this approach new techniques may not, by assumption, be 'retrofitted' to old equipment. What this analysis emphasises, however, is that labour productivity will depend negatively upon the average age of capital. Thus in the 1970s, as investment slowed, the average age of the capital stock increased and labour productivity fell in consequence. In the 1980s, there was exceptionally heavy scrapping, which lowered the average age of capital (on the reasonable assumption that generally speaking the oldest, least productive, equipment was scrapped first) and hence led to a rise in labour productivity.[1] As with the previous case, the evidence on the importance of this effect is not altogether clear-cut. Wren-Lewis[2] finds some evidence that investment plays a role in explaining recent improvements in labour productivity, while Oulton casts some doubts on the usefulness of the vintage capital model in explaining the growth of labour productivity in the 1980s.

There are, in addition to the arguments already noted, important demand influences upon productivity (especially marked in labour productivity as proxied by output per head) in the short and medium term. There is, for example, the well-known pro-cyclical movement in productivity, produced by the lagged adjustment of employment to changes in output produced by a change in demand. An important part of the empirical exercise in the next section is devoted to distinguishing these utilisation factors—often referred to as 'cyclical'—from underlying movements in labour productivity. A note of caution is required, however, in evaluating the cyclical component of productivity in the present decade, since output growth has been almost continuous, making comparisons with earlier periods of evidently cyclical (or at least fluctuating) growth very difficult. Indeed it is possible that the depressed and fluctuating state of demand in the 1970s was a *major* contributor to the marked slowdown in productivity growth during this period. On this view, changes in input prices, together with tightening policy responses, suggest a slowdown originating on the demand side, as growth in output declined, but employment only adjusted slowly and labour utilisation rates fell. Such a sequence of events may be part of the explanation of the slow growth in productivity, particularly in the second half of the 1970s, when there is some evidence that firms held on to workers in the (mistaken) view that demand was likely to recover.[3]

This brief resumé of some of the possible determinants of the trend in labour productivity suggests that there are reasons for expecting that trend to be improved in the 1980s, although it may be difficult to obtain precise quantification of the importance of these determinants. In the next section some evidence on the likely scale of that productivity trend is reviewed, although no attempt is made to adjudicate between the rival explanations of it.

Estimation of manufacturing productivity trends

There are general reasons for thinking that there has been an improvement in trend productivity over the 1980s, and the question addressed in this section is its likely size. The illustrations concentrate on the manufacturing sector.

These illustrations are directed at updating previous work; for total factor productivity, and for labour productivity using an employment equation. The examples taken are the production function estimated by Muellbauer[4] for total factor productivity, and the employment equation as estimated by Harvey, Henry, Peters and Wren-Lewis[5] for labour productivity. The illustrations show the effects of incorporating additional data, but as far as possible the original models have been used without significant amendment. In the case of the production function, time trends which originate at different starting points are used to proxy the effects of productivity improvements. The employment equation is estimated with a radically different representation of productivity, being a stochastic time trend. These different assumptions are applied in order to retain the assumptions used in the original estimates. There is a wider question of which is the most desirable assumption among these two alternatives. No attempt is made here to address this question.

(a) Total factor productivity

To estimate total factor productivity, it is assumed that real value added (Q) is dependent upon fully utilised inputs of labour (L) and capital (K) according to the production function

$$Q = f(L, K, t)$$

where including time (t) allows the relationship to shift over time. For simplicity the Cobb Douglas function with constant returns to scale may be used, written in logarithmic form as,

$$\ln Q = \alpha_0 + \alpha_1 \ln L + (1 - \alpha_1) \ln K + \theta t \qquad (1)$$

Given the problems in measuring capital, alluded to below, it may be thought that using a highly simplified structure like (1) is preferable to a more sophisticated assumption. Total factor productivity growth may be represented by θ, since this gives the addition to output not accounted for by variations in inputs. There is, however, a very important proviso to this; inputs must be properly measured, and variations for their rates of utilisation allowed for. In the case of labour, an attempt may be made at adjusting the labour input for variations in utilisation. It may also be that changes in the quality of labour occur sufficiently slowly not to affect the empirical results seriously. For capital, measurement and utilisation problems seem incomparably more difficult. There are

(1) See Oulton, N. 'Productivity, investment and scrapping in UK manufacturing: a vintage capital approach'. NIESR Discussion Paper No 148, 1988.

(2) Wren-Lewis, S. 'Supply, liquidity and credit: a new version of the Institute domestic econometric macro model'. *National Institute Economic Review* No 126, November 1988.

(3) See, for example, Darby, J and Wren-Lewis, S. 'Trends in manufacturing sector labour productivity'. NIESR, Working Paper, 1988.

(4) Muellbauer, J. 'Productivity and competitiveness in British manufacturing'. *Oxford Review of Economic Policy*, vol 2, no 3, Autumn 1986.

(5) Harvey, A, Henry, B, Peters, S and Wren-Lewis, S. 'Stochastic trends in dynamic regression models: an application to the employment output equation'. *Economic Journal* 96, 1986.

severe measurement problems—eg the assumption that the average service life is independent of economic conditions is evidently implausible, and, as many commentators have observed, scrapping must have been seriously affected by the two oil price shocks and the depressed state of aggregate demand in the late 1970s. Moreover, no direct measure of capital utilisation is available, though Brown[1] provides a method of adjustment based on transforming the CBI Industrial Trends Survey. Given these quite fundamental measurement problems, the parameter θ may best be interpreted as capturing not only technical progress but also measurement problems of the capital stock.

To make an allowance for labour utilisation, a direct, though imperfect, measure is provided by the number of overtime hours worked on average. This measure is clearly a useful one when utilisation rates in the economy are high. But at low levels of activity, when utilisation rates of labour are low, some firms may still pay for the full standard or normal working week even if some workers are not fully used for this period. In such circumstances average overtime hours will not be a good proxy for utilisation rates of labour.

Under certain conditions a non-linear function of overtime hours is a better all round estimate of average utilisation and has worked well in empirical applications,[2] and that is the approximation used here. This function is based on the total of weekly overtime hours divided by the number of operatives times normal hours. Another adjustment must be made for possible output bias. This is due to the argument that changes in raw material and energy prices led to the appearance of a productivity slowdown because of bias in the measurement of output. While this factor may indeed lead to an understating of output, it is generally thought that its size is not significant, although an allowance is made for it in the empirical estimates below.

Given these assumptions, the simplified production function given by equation (1) above can be estimated, with the exogenous time trend allowed to change in distinct phases. These phases are the period after the second oil price shock in 1979 and the period after the third quarter of 1980 when labour productivity began to show a marked improvement. Table A below then shows estimates of α and the parameters on the time trends for equation (2),

$$\ln Q_t = \alpha \ln L_t + (1-\alpha)\ln K_t + \gamma Z_t + \theta t + \sum_{1}^{2} \delta_i T_i \qquad (2)$$

where Z_t is a set of variables which includes the proxy measure for utilisation and the effects of output bias noted earlier. T_i are additional time trends for the two phases above. The estimates for α and the time trends given in Table A are for the period 1970 Q1 to 1987 Q4.

Table A
Key parameters of the manufacturing production function
(1970 Q1–1987 Q4)

α	θ	δ_1	δ_2	R^2	DW
0.685	0.00197	−0.0058	0.0125	0.98	1.6
(6.95)	(2.03)	(1.53)	(3.2)		

According to this result the trend element in this equation, which is equated with total factor productivity in manufacturing, has undergone several shifts. After falling in the period immediately following the second oil price shock, the trend recovered sharply at the end of 1980. To gauge the net effect of these shifts, assume that the other determinants of output given in (2) are held constant. Then after 1980 the trends make an overall contribution to total factor productivity of 3.47% (annualised). This figure is distinctly higher than the estimate provided by Muellbauer (based on data up to the end of 1985) of 2.76% annualised, reflecting the particularly rapid productivity growth of the past two years.

(b) Employment equations

Some insight into the possibility of a changed labour productivity trend may be obtained from estimated employment relationships. Although this is in part dependent upon the assumed structure of production (ie the form assumed for equation (2) above) it will also depend upon further assumptions made about markets, bargaining strategies and expectations formation. These issues are not discussed in the present note which concentrates upon the empirical results for a simple model. In the light of the discussion in the first section above, it can be expected that the employment relationship would be dynamic (reflecting adjustment costs), and would depend upon labour costs relative to capital costs (reflecting possible substitution between capital and labour), output (representing expected output) and a term representing labour productivity (σ). In this illustration, σ is assumed to be a stochastic time trend. The employment equation which is estimated is then:

$$\ln L_t = \alpha_1 \ln L_{t-1} + \alpha_2 \ln Q_t + \alpha_3 \ln Q_{t-1} + \alpha_4 \ln (PR)_t + \sigma \qquad (3)$$

where σ is the stochastic time trend and *PR* the ratio of labour cost to the cost of capital. Making the assumption that σ is a stochastic variable is a more general assumption than was made in estimating the production function in (a). One advantage of this approach is that it enables both the level and trend of σ to vary in a random way.[3] Table B presents an estimate of this relationship for the sample 1970 Q1–1987 Q4.

Table B
Employment-output relationship (1970 Q1–1987 Q4)

$\alpha 1$	$\alpha 2$	$\alpha 3$	$\alpha 4$
0.77	0.09	0.08	−0.004
(23.9)	(8.08)	(6.34)	(1.4)

(1) Brown, M. 'A formula for UK growth'. *Phillips and Drew Economic Briefing*, No 182, 1988.
(2) See Mendis, L and Muellbauer, J. 'Has there been a productivity breakthrough? Evidence from an aggregate production function for manufacturing'. Centre for Labour Economics, London School of Economics, Discussion Paper No 170.
(3) Further details are provided in Harvey, A, Henry, B, Peters, S and Wren-Lewis, S. 'Stochastic trends in dynamic regression models'. *Economic Journal*, 1986.

This estimated equation is generally similar to that estimated by Harvey et al for the period 1963 Q1–1983 Q3, which is reassuring as it suggests that the underlying behaviour of employment is stable.[1] What is interesting, however, is the estimate of the (smoothed) trend of labour productivity which is now obtained. As with the estimates for total factor productivity, this example indicates that the trend of labour productivity has improved in the 1980s. On average the trend component is estimated to be 3.0% per annum in the 1980s. This compares with a figure of 1.14% for the 1970s. It is possible to extend these estimates using earlier data from the 1960s, but the limited data which are available for relative factor prices *(PR)* preclude estimation of an equation like (3) over this longer data set. An alternative is to drop the relative price term, and estimate the resulting equation over data which includes part of the 1960s. Such an estimate gave an average value of the labour productivity trend of approximately 2.0% for the period 1965–75. On the basis of this admittedly imperfect comparison, there is some evidence that labour productivity in the 1980s may also have improved over its performance in the late 1960s and early 1970s.

Conclusions

This note has largely been concerned with presenting evidence of changes in the underlying productivity trend since 1980. According to the two related approaches, for total factor productivity and labour productivity respectively, the evidence is that the trend of productivity has improved noticeably. Because the two estimates have been obtained using different approaches, it is difficult to interpret the relationship between them in a precise way. The purpose of this note, however, is to show that the results of either approach imply that estimated productivity has increased in the 1980s compared with the 1970s. These estimates are subject to some uncertainty largely due to measurement problems in the underlying variables. The measurement problems with the capital stock, in particular those arising from making a proper allowance for scrapping, have already been alluded to. In addition, there is the possibility that investment is underrecorded, so that the growth in the capital stock may perhaps be higher than the recorded figures indicate, and this would tend to understate the contribution of capital to the improved productivity trend. Moreover, employment trends have been subject to downward revision, in turn tending to raise estimates of the growth in labour productivity. Such uncertainties mean that estimates of the precise changes in productivity trends have to be treated with some caution, though, it should be emphasised, there seems to be little doubt that a significant increase has occurred.

(1) The original did not include relative prices, unlike the equation reported here. Otherwise the equation is the same.