Fixed investment, the capital stock and factor utilisation

A recurring issue of considerable relevance at present is whether sufficient resources are being devoted to laying the foundations for continued economic growth. This question embraces a number of factors including education, training and fixed capital expenditure. This article[1] considers the last of these topics. It describes trends in investment and the capital stock since the mid-1960s. The effects on output per employee of changes in capital deepening and in the utilisation of employed capital and labour are also discussed.

Trends in investment[2]

Trends in non-residential fixed investment since the mid-1960s are shown in Charts 1 and 2. These represent gross non-residential investment as a proportion of output for the whole economy and for industrial and commercial companies (ICCs). In each case, the trends are shown both when investment and output are valued at actual prices and when they are valued at constant (1980) prices. This highlights the effects of changes in the relative price of investment goods: the relationship at constant prices indicates the share of real output devoted to replacing and expanding the capital stock, whereas the relationship at current prices shows the share of income spent on investment.

When measured at current prices, the ratio of non-residential investment to GDP, while showing cyclical fluctuations, changed little overall during the 1970s (Chart 1). However, it is clear that this ratio was sustained by an increase in the relative cost of investment goods, especially new buildings. Nearly 17% of current income was allocated to fixed investment throughout the 1970s, but, in volume terms, fixed investment absorbed around 18% of total output in the first half of the decade but nearer 16% in the second half. The current price ratio of non-residential investment to GDP fell sharply between 1979 and 1983 and it has since barely returned to even the lower levels seen during the 1970s. This weakness is more than accounted for by a fall in the relative price of investment goods since 1980 (contrary to the experience of the 1970s): the cutback in investment after 1979 accordingly looks smaller, and the subsequent recovery larger, when viewed in constant price terms. Indeed, in constant price terms, the share of non-residential investment in GDP in 1985 was higher than in any of the previous twenty years except for 1970.

Chart 1
Whole economy gross investment as a proportion of GDP

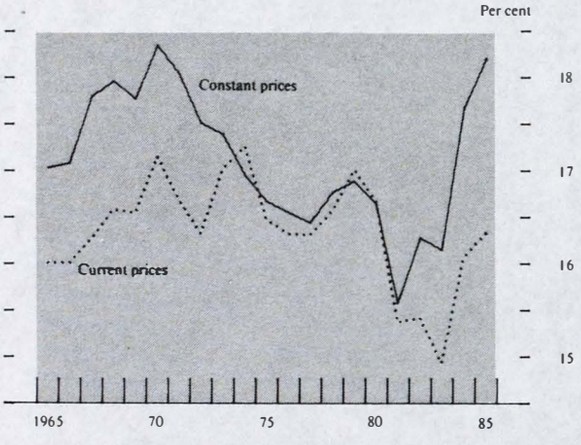
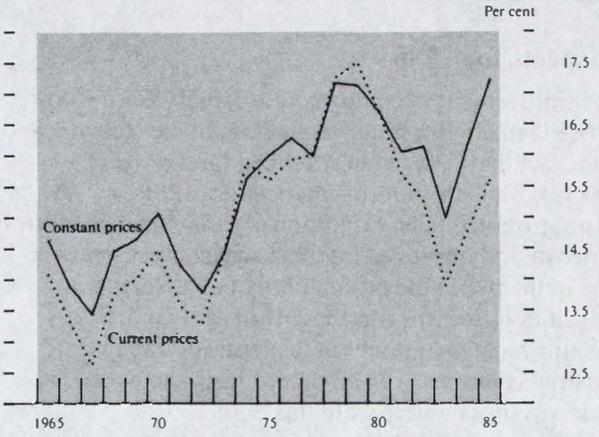


Chart 2
Gross investment by ICCs[a] as a proportion of ICCs' value added



(a) Including an estimate for leased assets.

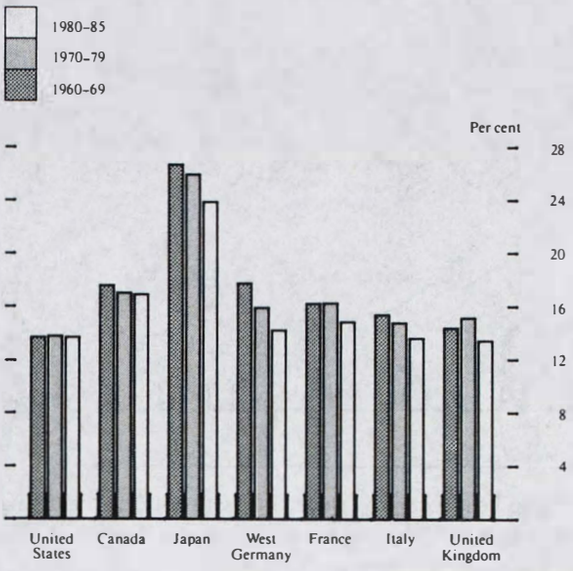
ICCs' investment (including assets leased) as a proportion of their net output[3] showed a distinct upward trend until 1979. There was a sharp decline in this ratio from 1979 to 1983, which was reversed in the following two years; in terms of constant prices, the ratio of ICCs' investment to their output in 1985 was the highest for more than twenty years.

(1) Prepared in the Bank's Economics Division mainly by D K Miles, P S O'Brien and M J Pratt.

(2) Conclusions about the size of the capital stock and the adequacy of investment for output growth are necessarily tentative. This is largely because it is difficult to estimate capital depreciation. Plant and machinery and other types of equipment deteriorate with time and use, but the rate of deterioration is generally unobservable and differs from one type of capital equipment to another. Inevitably, therefore, the statisticians who compile the national accounts fall back on rules of thumb regarding asset lives and rates of depreciation which, especially at a time of rapid technical progress or of economic upheaval, may not be very accurate. These problems make comparisons of the capital stock over time hazardous. This caveat should be borne in mind when reading the rest of this article.

(3) ie value added.

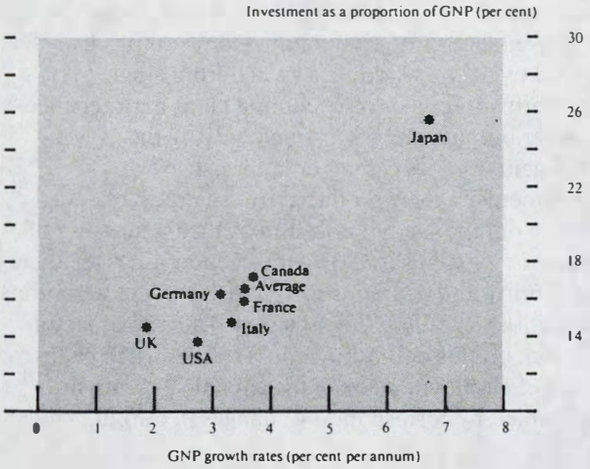
Chart 3
Gross non-residential investment[a] as a percentage of GNP



(a) At current prices.

Chart 3 gives an indication of the share of output devoted to gross non-residential investment in the major seven OECD economies from 1960 to 1985. The United Kingdom's experience is not out of line with that of other economies, with the exception of Japan. In Japan around one quarter of income has been used for investment compared with a little under two thirds that rate in the other major OECD countries. At first sight, Chart 4 might appear to suggest that a high share of investment in GDP and a high growth of output tend to go together. Econometric work, however, has shown that the relation depends heavily on the inclusion of Japan.[1] There are, in any case, several good reasons for suspecting that the relation between the growth of output and the investment to output ratio is far from exact. Although the volume of investment influences the pace at which the capital stock increases, capacity also depends on the employment of labour and other factors of production and on the efficiency with which production is organised. In addition, differences in the structure of industry and in relative factor prices will lead to significant differences in the capital intensity of production in different countries.

Chart 4
Growth rates and ratios of gross non residential investment to GNP in the major OECD economies 1960–85



The capital stock

Charts 5 and 6 show the annual rates of growth of the non-residential capital stock for the whole economy and for the manufacturing sector. In estimating the growth of the gross capital stock, no allowance is made for depreciation; instead it is assumed that investment goods make the same contribution to the capital stock for the whole of their estimated lifetime and are then scrapped. The charts also show estimates of investment relative to the capital stock where both flow and stock have been adjusted by the Central Statistical Office for estimated depreciation throughout the life of each asset.[2] These

Chart 5
Growth of the capital stock: manufacturing[a]

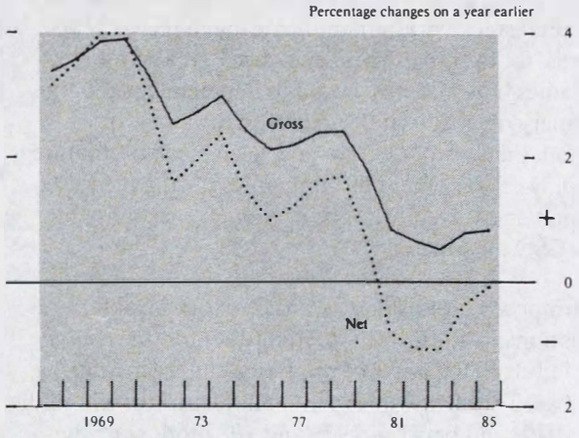
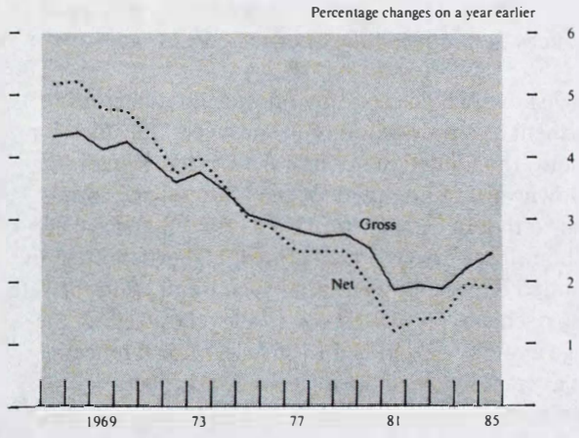


Chart 6
Growth of the capital stock: whole economy[a]



(a) 1985 figures estimated.

(1) See Rowthorn, R E. 'What Remains of Kaldor's Law' *Economic Journal*, volume 85, March 1975, pages 10–19.
(2) The CSO periodically revises its assumptions regarding asset lives. Assumed asset lives in the manufacturing sector, for example, were shortened significantly in the 1983 *National Income and Expenditure* (the Blue Book). 1985 figures for gross and net capital stocks are Bank estimates.

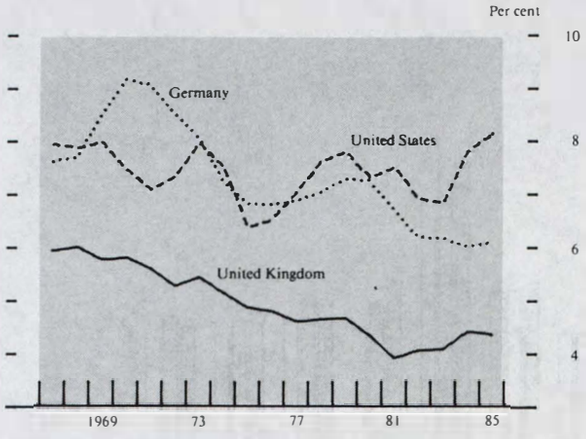
charts give some idea of the extent to which the capital stock has been renewed and expanded during the last twenty years. On these measures the whole economy capital stock, on both a gross and net basis, has grown by an average of 3% a year over this period. The average annual growth of the net capital stock of manufacturing industry has been lower (1½%), reflecting in part the changing sectoral composition of national output. It is apparent that a single year's investment has a comparatively small effect on the size of the capital stock. If investment in manufacturing in 1985 had been double what it was, for example, the gross capital stock would have been only 3½% higher. A policy of higher investment must be sustained for several years before it has an appreciable effect on the capital stock and hence on productive capacity.

Economic growth in the United Kingdom since the first oil shock has been generally below the rates experienced in the fifties and sixties, and Charts 5 and 6 show that the growth of the capital stock has slowed. This is particularly true of the manufacturing sector where the net capital stock grew at an average rate of 3% a year from 1967 to 1979, whereas, since then, it has contracted by ½% a year. Moreover, these estimates may understate the true fall in the capital stock within manufacturing in recent years. There is, for example, some evidence that a number of companies have recently begun to depreciate plant and machinery over shorter periods than formerly. In addition, there is thought to have been some premature scrapping of equipment by companies during the 1980 recession and this may not be adequately accounted for in the CSO's estimates.

Superimposed on this downward trend are sizable fluctuations, with the ratio of investment to the capital stock falling at the onset of recessions and rising during upswings. The sharpest falls in manufacturing were in the early 1970s and between 1979 and 1982 following the second oil shock. The first oil shock was, however, followed by a comparatively small fall in the investment/capital ratio; this may have reflected contemporaneous increases in the generosity of capital allowances that reduced the after-tax cost of investment.

Chart 7 shows whole economy non-residential gross investment as a proportion of the gross capital stock for Germany, the United States and the United Kingdom. The downward trend noted for the United Kingdom is similar to that in Germany; in the United States, where the labour force has grown at a much higher rate than in the United Kingdom, there is no such trend, with the rate having risen sharply since 1982 to a level exceeding the average over the period from 1967.[1] The differences in the average levels of the measured ratios between countries should be interpreted with caution since these

Chart 7
Non-residential sectors' gross investment as a proportion of gross capital stock[a]



(a) 1985 figures are estimates.

are likely to be affected by differing assumptions regarding asset lives to a much greater extent than are the broad trends in the ratios within each country.

'Normal' output and the capital stock

Changes in the capital stock directly affect the productive capacity of the economy. The relationship is, however, complex, depending on the availability and skills of labour, on the efficiency with which energy and raw materials are used, and on the extent to which new plant and machinery incorporate technical improvements. The problems involved in estimating these interrelationships between the various inputs to the production process and potential output are particularly difficult,[2] since potential or capacity output, which is of prime interest, is not observable; indeed, capacity is a rather nebulous concept in practice.

One approach to this problem, suggested by research at the OECD, is to define normal output as that level of output which is produced when capital, labour and other factors are employed at average levels of intensity.[3] This implies that, at normal rates of working, extra output can be achieved in the short run by making more intensive use of employed factors of production—for example, by increased overtime working, a switch from single to double shiftworking, or rescheduling plant maintenance. But higher output can be sustained only by the employment of more capital or labour, or by improvements in their productivity. The ratio of actual to normal output at a point in time is then a measure of the *intensity of factor use*. By construction it has an average value of unity and deviations from unity reflect variations in the utilisation of *employed* factors. The rate of factor utilisation, on this definition, only changes when changes in levels of employment or in the capital stock are not accompanied by corresponding changes in output. The

(1) This recent increase in the ratio in the United States partly reflects tax incentives for investment enacted in 1981.

(2) See, for example: Desai, M. *Applied Econometrics*. Oxford: Phillip Allen, Heddington (1976). Wallis, K. *Topics in Applied Econometrics* (2nd edition). Oxford: Basil Blackwell, 1979.

(3) This approach is described in Helliwell et al (1984). NBER Working Paper No 1465 and in Helliwell et al (1985). OECD Working Paper No 26. The Appendix offers a summary of work within the Bank to apply the approach. An earlier study within the Bank of capacity utilisation in manufacturing industry was described in the December 1971 *Bulletin*, pages 490–96.

utilisation measure, in other words, relates actual output to the output which, on average, the employed factors would be expected to produce. In estimating normal output, it is numbers employed, rather than hours worked, which is used as the measure of labour input. This is because changes in average hours worked per employee are highly cyclical, largely reflecting fluctuations in overtime. It is consequently appropriate to use numbers employed in estimating normal output as this is independent of changes in utilisation.

Charts 8 and 9 show estimated utilisation rates since 1967 for factors employed in the non North Sea business sector[1] and in the manufacturing sector. These suggest that the intensity with which employed labour and capital are utilised has shown considerable variability. For the business sector, the ratio of actual output to the level of output consistent with 'normal' utilisation of employed factors peaked in 1972 at almost 110%, but was only 90% in 1980. For manufacturing companies, the range is even greater, with utilisation estimated to be 112% at the end of 1973 and around 85% in 1980. Thus the range of quarterly output produced with given levels of factor employment has been over 20% of normal output.

Chart 8
Factor utilisation and investment: non North Sea business sector

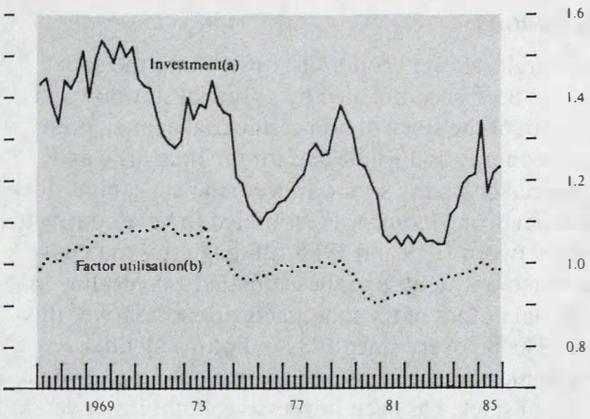
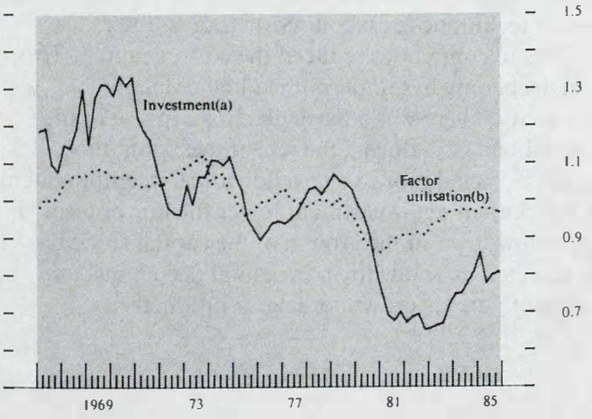


Chart 9
Factor utilisation and investment: manufacturing



(a) Gross investment as a percentage of gross capital stock: 1985 figures are estimates.
(b) Ratio of actual to normal output.

Charts 8 and 9 show that gross investment as a proportion of the gross capital stock has been related to factor utilisation. Periods of higher than average utilisation, for example, have tended to be followed by rises in investment.[2] This relationship suggests that firms respond to divergences between actual and potential output by adjusting their levels of investment. The peak in manufacturing investment in 1970, for example, followed a period of two and a half years when factor utilisation had been about 5% above normal. On the other hand, the dramatic fall in investment in manufacturing in the early 1980s occurred after factor utilisation had been low and falling for several quarters. For the business sector, the sharp recovery in investment as a proportion of the capital stock which began in 1983 followed a steady rise in utilisation from a low point in 1980.

Changes in investment are likely to be part of a wider response to eliminating a discrepancy between normal output and expected demand. Indeed, changes in the numbers of employees are likely to be the principal short-run means of adjustment. This is illustrated by the recent experience of the manufacturing sector, where numbers employed fell by nearly 30% between 1979 and 1985 and the net capital stock contracted by an estimated 2¾%. When allowance is also made for technical progress and for changes in energy use, normal output is estimated to have fallen by only 14% and factor utilisation to have been much the same in 1985 as in 1979. It is estimated that the reduction in employment alone would have more than accounted for the decline in normal output and the fall in the net capital stock over this period had a relatively minor effect.

Capital deepening and labour productivity

Gross fixed capital per employee in the non North Sea business sector has doubled since the mid-1960s (Chart 10). Table A shows the separate contributions of changes in capital stock and in employment to capital deepening (increases in the ratio of capital to labour) since

Table A
Contributions to capital deepening in the business sector

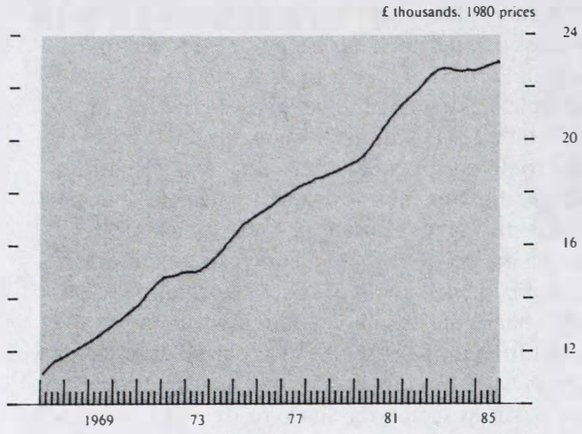
Per cent per annum

Periods of rising (+) and falling (−) utilisation	Growth of gross capital stock	Changes in employment	Rate of capital deepening(a)
	1	2	3
1967–72 (+)	4.8	−1.0	5.8
1972–76 (−)	3.7	−0.6	4.3
1976–79 (+)	3.4	0.7	2.7
1979–81 (−)	3.0	−2.0	5.0
1981–85 (+)	2.7	—	2.7

(a) ie column 1–column 2.

(1) The output of the non North Sea business sector is total national output minus general government output, the output of public corporations and output from the North Sea. It includes manufacturing industry.
(2) This relationship is confirmed by econometric work within the Bank. Of course, other influences affect the level of investment.

Chart 10
Gross capital per employee[a]: non North Sea business sector



(a) 1985 figures are estimates.

1967. The sub-periods analysed are years of rising and falling factor utilisation. The picture throughout the 1970s was of a gradual deceleration in capital deepening, both because the growth of gross capital stock was slowing and because of a movement from a slow fall in employment to a small rise in the late 1970s. The sharp downturn in economic activity from 1979 to 1981 saw an unusually rapid growth in capital per employee, which was due mainly to a sharp cut in employment. This, however, looks exceptional; the recovery since 1981 has been accompanied by a return to slower rates of capital deepening akin to those seen in the late 1970s. Over the whole period since 1967, growth of the capital stock made a larger contribution to capital deepening than falls in employment. However, as was seen in Charts 5 and 6, the rate of growth of the capital stock has slowed steadily since the late 1960s—from a rate of almost 4½% per annum in 1967–72 to just 2½% in 1981–85.

Table B
Accounting for productivity growth in the non North Sea business sector[a]
Per cent per annum

Periods of rising (+) and falling (−) utilisation	Output per head	Employed factor utilisation	Normal output per employee		
			Total	*of which attributable to:* capital deepening	technical progress[b]
	1	2	3	4	5
1967–72(+)	+3.9	+1.8	+2.0	+1.2	+0.8
1972–76(−)	−1.1	−2.6	+1.6	+0.7	+0.9
1976–79(+)	+1.6	+0.4	+1.2	+0.3	+0.9
1979–81(−)	−2.3	−4.0	+1.7	+0.8	+0.9
1981–85(+)	+3.0	+1.8	+1.2	+0.4	+0.8
1967–85	+1.6	—	+1.6	+0.7	+0.9

(a) Relation between the columns (subject to rounding) is:
(1) − (2) = (3) = (4) + (5)
(b) Is effectively a residual. See footnote (1) below.

Table B separates the temporary effects of changes in employed factor utilisation on labour productivity in the non North Sea business sector from the more lasting effects of capital deepening and technical progress.[1] This highlights the considerable short-run impact that fluctuations in factor utilisation have had on measured output per employee. In the downturn from 1979 to 1981, for example, output per employee fell by 4½% but this was more than accounted for by a fall in factor utilisation from 99% to 91%. More recently, more than half of the 12% rise in output per employee from 1981 to 1985 can be attributed to an increase in the utilisation of capital and labour.

Capital deepening, with newer plant and machinery incorporating technical advances, has helped increase labour productivity and hence the real incomes of those in work. There appears to have been some slowing in the 1970s in the underlying growth of normal output per employee; this would seem in part to be a consequence of the slowdown in capital deepening, which in turn mainly reflects a slowdown in the growth of the capital stock. The growth of normal output per employee since 1979 is estimated to have been about the same as in the 1970s.

Conclusions

The generally slower economic growth since the early 1970s has been accompanied by a gradual slowdown in the growth of the stock of non-residential capital, both for the economy as a whole and for the industrial and commercial company sector. Indeed, the net capital stock of manufacturing industry is estimated to have contracted by 2¾% between 1979 and 1985, although this may have contributed only a little to the estimated 14% decline in the normal output of the manufacturing sector over this period. The recovery since 1982 in non-residential investment, whether measured against output or against the capital stock, has been impressive, but it is not yet clear whether this represents a reversal of the trends of the 1970s.

The 1960s and 1970s saw a switch towards capital intensive techniques as labour costs rose and tax incentives to companies reduced the cost of capital. This capital deepening has underpinned higher labour productivity. There was a particularly sharp rise in the capital/labour ratio during the recent recession: this, however, reflected more a sharp downturn in employment than a pickup in net investment. Over the longer term, a gradual slowdown in the growth of the capital stock has been reflected in a slowdown in capital deepening, and subsequently in the growth of labour productivity.

(1) The term technical progress is used in its widest sense and embraces improvements in organisation, as well as technological innovation. The methodology behind Table B is described in the appendix.

Appendix

(a) The estimation of normal output

Separate production functions for manufacturing industry and for the non North Sea business sector were estimated. Their construction relies heavily on research by Helliwell et al (1984). Normal output (as defined in the main text) is related to the levels of employment, of energy use and of the capital stock. The estimate of normal output is constructed in two stages. First, data on the capital stock, on gross investment and on the relative costs of energy to capital are used to define a composite capital/energy aggregate which is combined with labour input at the second stage to define normal output. The capital/energy variable (or the capital/energy 'bundle') will be termed *KE* and can be written:

$$KE_t = f(I_{t-i}, CE_{t-i}, S_{t-i}, K_t, R) \qquad (1)$$
$$i = 1, 2, 3 \ldots\ldots N$$

Where I_t is gross investment at time t
CE_t is the relative cost of energy to capital at time t
S_t is the scrapping rate of the gross capital stock at time t
K_t is the gross capital stock at time t
R is the proportion of the capital stock for which the energy requirement is flexible

The capital/energy bundle in place at time t largely reflects investment decisions and factor prices prior to t. The relative cost of energy to capital is constructed from data on the prices of fuels, on the investment allowances to firms, on the price of new investment goods, on tax rates on profits and on depreciation. Scrapping rates are inferred from data on the gross capital stock and scaled up slightly to allow for possible underestimation by the CSO. R is estimated by a grid search technique.

The capital energy bundle in place at time t thus reflects investment decisions and factor prices for many years prior to t. Past relative prices are relevant because the energy requirement today associated with capital goods purchased in the past is likely to be highly dependent upon the perceived advantages of the energy intensiveness of production techniques at the time of purchase. These advantages are assumed to depend on the relative costs of capital and energy at the time of purchase.

The capital energy bundle is combined with employment in a constant elasticity of substitution[1] production function to define normal output. This can be written:

$$\hat{Q}_t = (\alpha\ (EE_t)^{-r} + \beta\,(KE_t)^{-r})^{-1/r} \qquad (2)$$

$$EE_t = L_t(1+g)^t \qquad (3)$$

$\hat{Q}_t$ is normal output at time t
EE_t is effective units of employment at time t
r = substitution parameter between *KE* and *EE* ($-1/(1+r)$ is the elasticity of substitution)
L_t = employment
g = rate of labour-augmenting technical progress

Output is measured *gross* of energy use and labour input is measured in effective units by augmenting numbers employed by a measure of the growth of disembodied labour productivity over time. For this study pure labour productivity is assumed to grow at a constant rate (g).

The unknown parameters of equations (1)–(3) are derived from an analysis of the path of actual output (Q) and from the data on employment of factors of production and on relative prices. For this study some parameter estimates from the earlier research of Helliwell et al were used[2] while other parameters (eg α and β from equation (2) and the rate of growth of 'pure' labour productivity) were directly estimated.

It should be emphasised that, inevitably, uncertainty exists over the accuracy of these parameter estimates. In particular, since normal output is unobservable, direct comparison of the production function predictions with actual outturns is not possible. Some indirect evidence for the overall plausibility of the parameter estimates can be gauged from the constructed series for factor utilisation for manufacturing and the non North Sea business sector (Charts 8 and 9). The pattern of intensity of factor use revealed in the charts fits in with evidence on capacity utilisation (eg from CBI surveys) and lends some weight to the procedure followed here in constructing the production functions.

(b) Estimating the contributions to growth of output per head

Measured labour productivity equals actual output (Q) divided by the workforce (L). Actual output is, in turn, equal to normal output ($\hat{Q}$) multiplied by factor utilisation $Q/\hat{Q}$. Thus:

Q/L = (factor utilisation). $\hat{Q}/L$

Normal output per worker $(\hat{Q}/L)$ can be viewed as depending on capital per worker (K/L) and technical progress. If this is so, the change in output per head can be expressed as the sum of three components which are: (i) the impact of changes in factor utilisation (ii) the impact of capital deepening (changes in K/L) and (iii) a residual effect from technical progress.

(1) So called because a given percentage change in relative factor costs yields a change in relative factor uses which is a fixed proportion of the change in costs.

(2) eg r was set equal to $\frac{2}{3}$ which gives an elasticity of substitution between *KE* and *EE* of -0.6.