Explaining Economic Growth*

This article analyses the methodological issues which arise in explaining European economic growth in the 1950s. The main concern is with Edward Denison's *Why Growth Rates Differ*[1] — which is the outstanding empirical contribution to growth literature. Denison exploits the complex source material with unparalleled skill, and has performed an important service by his boldness and intuition in filling quantitative gaps with intelligent guesswork. His growth analysis is a major extension of the national accounting framework. His energy, self-assurance and perseverance in quantification have raised the quality of the growth discussion by forcing his critics to be more articulate and rigorous than they might otherwise have been.

Denison does not say much about the theoretical implications of his approach, nor does he consider policy implications explicitly as he did in his earlier book on U.S. growth.[2] He writes for technocrats rather than policy-makers, dealing with proximate rather than ultimate causality. This was a deliberate choice on his part, and he cannot reasonably be criticised for failing to do something unintended. But I think he seriously underestimates the role of capital formation and trade liberalisation in the acceleration of Europe's postwar growth, and that some of his implicit policy conclusions are misleading. I also disagree with two of his basic rules of thumb concerning measurement of labour quality. This paper presents alternative

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1 See E. F. Denison (assisted by J. P. Pouillier), *Why Growth Rates Differ*, Brookings, Washington, 1967.

2 See E. F. Denison, *The Sources of Economic Growth in The United States and the Alternatives Before Us*, Committee for Economic Development, New York, 1962.

estimates within the framework of Denison's model which (I think) provide a better explanation of the growth experience of the 1950s.[3]

The analysis is divided into several sections: (I) description of Denison's implicit model and its historical origins; (II) analysis of his treatment of output; (III) of capital inputs; (IV) of labour inputs; (V) of other components of growth; (VI) conclusions. Denison deals with levels of productivity as well as trends, but here the concern is only with trends.[4] Throughout we refer to Denison's estimates for 1950-62 and not to those for the sub-periods 1950-55 and 1955-62.

I. The Intellectual History of the Denisonian Model

Denison explains growth by use of an index of "total factor productivity". The word "total" is used because all factor inputs (labour and various kinds of capital) are combined into a comprehensive index and the rest of growth is attributed to the rise in productivity. "Productivity" in this context is smaller than that shown by the "partial" productivity approach, e.g. in labour productivity indices where output is explained in terms of only one input, labour, and a productivity concept which embraces all other sources of growth. The "partial productivity" formula for labour productivity is:

$$O = LP \qquad [1]$$

where O = output, L = labour input, and P = labour productivity.

An alternative "partial" productivity formula for capital is:

$$O = KP^1 \qquad [2]$$

where K = capital, and P^1 = capital productivity. (The superscript distinguishes productivity in this sense from labour productivity).

3 The interpretation of European growth which I advance here, is similar in emphasis to that in my book, *Economic Growth in the West*, Allen and Unwin, 1964, though that book was primarily concerned with the impact of economic policy and did not contain an explicit model of the growth process. The argument there was closer to that of Kaldor's technical progress function and Salter's analysis than to the present production function approach.

4 See A. Maddison, "Comparative Productivity Levels in the Developed Countries", this *Review*, December 1967 for a comment on Denison's work on levels of performance.

The total factor productivity approach had its origin in the work of P. H. Douglas who first experimented with "production functions" in 1928 as a means of empirical verification for theories of income distribution.[5] Douglas was interested in seeing how the proceeds of industrial output were divided between labour and capital. His function explained growth in the following way:

$$O = aL + (1 - a)K \qquad [3]$$

where O equals output, L equals employment, K the capital stock, a the share of labour in total income and (1 — a) the share of capital in income.

Douglas explained all growth in terms of inputs of labour and capital, and his growth equation had no productivity component. This was partly because he dealt with a period in which technical progress was slow, partly because his data were defective.

Later research by Tinbergen, Stigler, Schmookler, Abramovitz, Niitamo, Aukrust and Kendrick[6] showed that growth of the combined inputs of labour and capital does not normally "explain" the whole of output growth. These writers restored the role of productivity in explaining growth and their formula was therefore:

$$O = aL + (1 - a)K + P^2 \qquad [4]$$

where P^2 is total factor productivity.

Kendrick's ambitious study of "total" factor productivity showed that factor inputs accounted for less than half of U.S. growth in the period 1869-1957. Subsequent investigators have tried both to reduce the size of the "productivity" component by "augmenting" the estimates of factor input and to break down "productivity" into its

5 See P. H. Douglas, "Are there Laws of Production", *American Economic Review*, March 1948, for a retrospective review of his work.

6 See J. Tinbergen, "Zur Theorie der langfristigen Wirtschaftsentwicklung", *Weltwirtschaftliches Archiv*, Band 55, Heft 1, 1942; G. J. Stigler, *Trends in Output and Employment*, N.B.E.R., New York, 1947; J. Schmookler, "The Changing Efficiency of the American Economy, 1869-1938", *Review of Economics and Statistics*, 1952; M. Abramovitz, "Resource and Output Trends in the U.S. Since 1870", *American Economic Review*, May 1956; O. Niitamo, "The Development of Productivity in Finnish Industry 1925-1952", *Productivity Measurement Review*, November 1958; O. Aukrust, "Investment and Economic Growth", *Productivity Measurement Review*, February 1959; J. W. Kendrick, *Productivity Trends in the United States*, N.B.E.R., Princeton, 1961.

components so that the causes of growth can be made as explicit as possible.

An important contribution to the literature on augmented factor inputs was made by Salter and Solow [7] who showed convincingly that technical progress was not an autonomous source of growth but makes its impact on output mainly by being embodied in new capital. They argued that capital comes in vintages, and that each new year's increment to the stock is different and better than that of the previous year. They advanced plausible reasons for believing that the aggregate impact of technical progress is a fairly smooth (exponential) process and not jerky as Schumpeter had suggested. In its extreme form the Solow formula "embodied" all technical progress in capital and had no productivity component:

$$O = aL + (1 - a)\ (K + \lambda_k) \qquad [5]$$

where λ_k is a shorthand expression reflecting the embodiment of a steady percentage (exponential) addition to productive capacity associated with the gross investment of each year. Solow experimented with various values of λ_k designed to eliminate the productivity component. He assumed as a constraint that (a) should take a value reasonably near labour's recorded share of national income, and suggested that the rate of postwar technical progress had been about 4 to 5 per cent a year.[8]

Denison rejects Solow's "fully embodied" version of technical progress because it gives an implausibly high value to λ_k. Implausible because the rates Solow postulates are incompatible with what we know about the lives of assets — which would be scrapped earlier

7 See W.E.G. Salter, *Productivity and Technical Change*, Cambridge University Press, 1960; R.M. Solow, "Investment and Technical Progress", in K.J. Arrow, S. Karlin and P. Suppes, eds., *Mathematical Methods in the Social Sciences*, 1959. Solow's views are set out at greater length in *Capital Theory and the Rate of Return*, North Holland, Amsterdam, 1964.

8 See R.M. Solow, *Capital Theory and the Rate of Return*, North Holland, Amsterdam, 1964, pp. 80-1: "It may strike you that 4 or 5 per cent a year is a high rate of technical progress for an economy whose output has grown only at 3 per cent a year on the average over the long period, and whose labour force and stock of capital have been growing too. The apparent paradox is resolved by the recollection that λ is the annual rate at which the productivity of capital improves. But a 1 per cent increase in the effective stock of capital yields only an α per cent increase in output, if α is the elasticity of output with respect to effective capital. So a rough estimate of the contribution of technical progress to the growth of output can be obtained by multiplying each λ by its corresponding α". For α read the a in our equation, and for λ read λ_k.

than they are, if Solow's extreme assumptions were correct.[9] Furthermore, the fully-embodied version of Solow's argument (formula 5) means that embodied technical progress is a catchall expression which includes the impact of education, economies of scale, gains from economic integration, disembodied technical progress, etc., which should be specified separately. What is surprising is that Denison's repudiation of the Solow-Salter argument was virtually complete though he does not reject it in principle and even makes a plausible suggestion about the likely quantitative magnitude of embodied technical progress. His insistence that the embodiment question is unimportant is both perversely argued and has misleading implications for policy.[10]

About the same time that Solow suggested augmented concepts of capital input, Schultz stressed the important effects of education on economic growth by raising the quality of human capital. The point was quickly developed by Denison, who changed the Schultz formulation,[11] and incorporated other dimensions of quality change

9 See E.F. Denison, "Capital Theory and the Rate of Return", *American Economic Review*, September 1964.

10 See E.F. Denison, *Sources of Economic Growth*, pp. 234-7, 254-5, E.F. Denison, "The Unimportance of the Embodied Question", *American Economic Review*, March-May 1964; and E.F. Denison, *Why Growth Rates Differ*, pp. 144-50. In all of these places he argues as if the embodiment effect operated only in cases where the average age distribution of the capital stock changes (and even this in a very narrow sense, i.e. abstracting from the impact of changes in the distribution of capital between construction and equipment). If one defines the embodiment question in this extraordinarily limited way, its influence is not too important because the average age of the capital stock does not normally change very dramatically when age structure is defined in this narrow sense. But nobody but Denison would restrict the meaning of the argument in this way. What Denison is doing, in Salter's terminology, is to assume that embodied technical progress makes its impact only by changes in age structure which alter the ratio between average and best practice at different dates, but most people define embodied technical progress in terms of changes in the productivity of average practice at different dates. It seems inconsistent that Denison does make allowance for his relatively unimportant element of embodiment, whilst ignoring the bigger components. In other places he argues against the Solow hypothesis on the grounds that it is impossible to know what the rate of embodied progress is, but he has to postulate its magnitude to apply his limited embodiment procedure, and he is willing to postulate a rate of disembodied progress. See R.R. Nelson, "Aggregate Production Functions and Medium-Range Growth Projections", *American Economic Review*, September 1964, p. 582, for an elegant statement of the issues.

11 See T.W. Schultz, "Education and Economic Growth", in *Social Forces Influencing American Education*, Chicago, 1961, and "Investment in Human Capital", *American Economic Review*, March 1961; E.F. Denison, *The Sources of Economic Growth*, *op. cit.*, 1962; M.J. Bowman, "Schultz, Denison, and the Contribution of 'eds.' to National Income Growth", *Journal of Political Economy*, October 1964.

in his measure of labour input, including a rather controversial assumption about work intensity. The general form of the Denisonian formula is shown below (formula 6):

$$O^1 = a(L + \lambda_L) + (1 - a)\ (K + \lambda^1_k) + P^3 \qquad [6]$$

where λ_L represents in shorthand form the impact of education and other quality adjustments to labour; λ^1_k (much smaller than Solow's λ_k) represents Denison's adjustments to the capital stock; P^3 is the productivity element (which is smaller than P^2 because the augmentation of K and L has given factor inputs a greater explanatory role). O^1 is a slightly modified version of O.

The weights given to labour (a) and capital (1 — a) in the formulae cited above are their relative shares in (contribution to) national income (or gross national product). The rationale for this weighting system is the marginal productivity theory of distribution. Denison assumes that factor prices are proportional to marginal product and that factor shares give a reasonable approximation to the elasticity of output with respect to each factor. Some writers would disagree with this procedure either because of imperfections in the market or for more fundamental reasons. Though the use of income shares as weights is a matter of controversy, there is, unfortunately, no other generally acceptable alternative. Some observers have attempted to estimate the weights by empirical (regression) procedures, which usually give capital a bigger weight,[12] but it seems preferable to use weights which are based on an explicit theory (however questionable) and to let all the uncertainties accumulate as a residual unexplained component of P^3 rather than imbed them in the weighting system and assume that they thereby disappear.[13]

12 See R. Nelson, "Aggregate Production Functions and Medium Range Growth Projections", *American Economic Review*, September 1964.

13 The theoretical discussion on production functions is extremely complex and many of the theoretically feasible influences on growth are not measurable. Furthermore, there is still fundamental disagreement in approach between the neo-classicists and the Cambridge School. The controversies have been bitter because of the political implications of different theories of distribution. See M. I. Nadiri, "Some Approaches to the Theory and Measurement of Total Factor Productivity: A Survey", *Journal of Economic Literature*, December 1970, for a comprehensive survey; and M. Brown, *On the Theory and Measurement of Technological Change*, Cambridge University Press, 1966, for an analysis of C.E.S. production functions, biased technical change, etc. See also C. Kennedy and A. P. Thirlwall, "Technical Progress: A Survey", *Economic Journal*, March 1972.

Denison's approach follows in the tradition of earlier writers but is distinguished by its degree of detail, the larger range of growth influences considered and the number of countries covered. In all, he deals with about 30 identified sources of growth.

Formula 7 spells out Denison's approach by stating his "production function" explicitly[14] as follows:

$$\left[O + (r + s - t - z)\right] = y\left[a\left(L + (n + u + v + w)\right) + (1 - a - b - c - d - e)\left(K + (f + g)\right) + bH + eI + dJ + m + p + q + x + \alpha\right] \qquad [7]$$

On the left-hand side of the equation, O is net national product at factor cost; r and s are adjustments to output to offset cyclical and weather fluctuations; t is a conceptual adjustment to output in Belgium and France to make it comparable internationally; z is an adjustment to convert the measure of output in Europe from European to U.S. prices. The items r, s, t and z can equally well be put on the right-hand side after the square brackets as "explanations" of growth instead of treating them as measurement items.

On the right-hand side, we have y, the percentage adjustment (to everything within square brackets) to represent economies of scale (10 per cent in the U.S., 11.5 per cent in Italy, 13 per cent in Norway, 12 per cent in Belgium, Denmark and the Netherlands and 11 per cent in other countries); a is the share of labour in national income; L is employment; n, u,[15] v, w are characteristics modifying labour input (hours, age-sex, work intensity, and education).

The next items, up to and including J, represent the impact of capital. Capital is divided into four operational categories: enterprise plant and equipment (K); housing (H); net foreign investment (J) and inventories (I). The other two categories: land and general government assets, have no explanatory role in his system. 1 — a — b — c — d — e is the share of business plant and equipment in

14 Denison kindly supplied me with an unpublished paper "Production Function Implicit in Why Growth Rates Differ", but the expression he uses is a little different from that given above.

15 In fact u (the adjustment for hours) is the result of a complex calculation involving six items; holidays, weekly hours, incidence of sickness, strikes, bad weather, and intensity of work.

national income, i.e. total income minus the shares of housing (b), land (c),[16] foreign investment (d), and inventories (e); K is the input of business plant and equipment; f is an age adjustment for business plant and equipment; g is a capacity use adjustment for business plant and equipment; bH is income from housing; eI is income from inventories; dJ is income from foreign capital.

Thus far, the items in the square bracket on the right-hand side have been factor inputs; the remaining items: m, p, q, x, and α are explanations of factor productivity. m is the gain in output associated with movement of labour out of agriculture and self-employment; p reflects economies of scale due to increasing concentration of population in local markets; q is the gain in output from reduction of trade barriers; x represents gains from advances in knowledge (disembodied technical progress); α is the unexplained residual.

In 1967, D. W. Jorgenson and Z. Griliches published an article which claimed (for he U.S.A.) to explain virtually all growth by augmented factor inputs. They assert that Denison's P^3 simply reflects measurement error. Their growth formula is equivalent to formula 6 without the last item (P^3), thus taking us back in a more sophisicated form to the Cobb-Douglas formulation. They make three important adjustments to the Denisonian measure of capital's role. Firstly, they "correct" for changes in the measurement of capital. This is not quite the same as Solow's embodiment effect. They argue rather that capital goods are usually over-deflated by conventional price indices, which measure inputs into the capital goods industry rather than its output. The point is valid, but their procedure is cavalier and has been rightly criticised by Denison. (They deflated the stock of equipment by the price deflator for consumer durables instead of that for producer durables. Inventories were deflated by the index for consumer goods). Secondly, and this is their main point, they argue that growth accounting should be concerned with the flow of services from capital rather than the stock. They allege that there have been major changes in the degree of utilisation of capital and suggest a measure of this (changes in the use of electric motors in manufacturing) which considerably augments the input of capital. Thirdly, they raise the explanatory role of capital by dealing in terms of gross

16 As the stock of land does not increase, this item has zero importance as an explanation of variations in growth rates.

output and using weights including depreciation. In the latest version of their writings, capital's share in total product is over 40 per cent, compared with less than 30 in Denison's study. This increases the role of capital as an explanatory factor, because capital grows faster than labour. Denison argued that their first two adjustments were not reasonable and they have since modified their position substantially, so that their present formula for the U.S.A. contains an item, P^4, which is smaller than Denison's P^3 but not much smaller.[17]

II. Output

Denison defines output as net national product at factor cost, and his boundary of economic activity is the same as in the standardised national accounts system. This enables him to exploit figures already available without a great deal of fundamental research of his own.[18] I prefer to use an augmented version of G.N.P. rather than national income, i.e. I include depreciation (for reasons explained in the section on capital below), and I impute an income from government capital.[19] The difference does not affect the output measure significantly but it has an important effect on the size of the

17 See D. W. Jorgenson and Z. Griliches, "The Explanation of Productivity Change", *Review of Economic Studies*, July 1967, E. F. Denison, "Some Major Issues in Productivity Analysis", *Survey of Current Business*, May 1969 (this issue includes a revised reprint of Jorgenson and Griliches); L. R. Christensen and D. W. Jorgenson, "The Measurement of U.S. Real Capital Input 1929-1967", *Review of Income and Wealth*, December 1969; L. R. Christensen and D. W. Jorgenson, "U.S. Real Product and Real Factor Input 1929-1967", *Review of Income and Wealth*, March 1970; D. W. Jorgenson and Z. Griliches, "Issues in Growth Accounting: A Reply to Edward F. Denison", Harvard Institute of Economic Research, Discussion paper 215, November 1971; D. W. Jorgenson, "Measuring Economic Performance", mimeographed paper presented to Conference on Research in Income and Wealth, November 1971, Princeton. In fact there was an earlier and briefer discussion between these protagonists which covered many of the same points, see Z. Griliches and D. W. Jorgenson, "Sources of Measured Productivity Change: Capital Input", *American Economic Review*, May 1966, and Denison's comment in the same issue.

18 Some of the earlier growth analysts like Douglas dealt with smaller aggregates like industrial production, and Jorgenson and Griliches have limited the scope of their output concept by excluding government. Kendrick used both the Department of Commerce and the Kuznets concepts of output.

19 There is something to be said for extending the output concept to include repair and maintenance, as is done in Norway and Sweden. Repair and maintenance is, after all, an important activity which has an impact on growth, and it is a pity to ignore it in this context. Given the lack of standardised data for this gross/gross concept, we shall simply stick to G.N.P., but it is obvious that inclusion of repair and maintenance could increase the role of capital as an explanatory factor in growth.

weights for capital. The differences can be seen by comparing Tables 1 and 2.

Denison feels that measured growth rates in O.E.C.D. countries are highly comparable. He says "I do not believe any large part of the big differences among countries in growth rates is likely to be ascribable to estimating errors, procedural differences, or choice of base years".[20] Recently T. P. Hill has sounded a note of caution on the comparability of the figures,[21] but as he has not suggested any specific amendments, we procede on the assumption that the figures for these countries are comparable as amended by Denison.

Denison makes four adjustments to the national income measure, which are indicated in Table 1. I have assumed that the same corrections apply to my augmented G.N.P. figure in Table 2. I have also imputed a flow of service income arising from use of general government assets (roads, hospitals, schools, etc.), but this imputation does not affect the measured growth of output.

Denison's adjustments are as follows:

(a) two adjustments to offset short-term disruptions of a cyclical or irregular character which affect the movement of output;

(b) a small downward correction for France and Belgium because the measure of output in the service sector exaggerates their growth compared wih that in other countries (which use different measurement conventions);

(c) the last adjustment is quite substantial. This correction arises from the fact that different countries have different price structures. The price structure is related in a fairly systematic way to the level of real income per head, which affects the pattern of

20 See *Why Growth Rate Differ*, p. 17. This feeling was shared by Beckerman and McGibbon who were successive heads of the O.E.C.D. National Accounts Division. See McGibbon, "The Statistical Comparability of Rates of Growth of Gross National Product", *Productivity Measurement Review*, O.E.C.D., Paris, February 1964; W. Beckerman and Associates, *The British Economy in 1975*, C.U.P., 1965, p. 14. Beckerman said "A detailed study has been made, at the Organisation for Economic Co-operation and Development, of the extent to which differences in methods and data deficiencies are likely significantly to affect the comparison of growth rates; it has been found that, among the more developed countries, no important incomparability could possibly arise from these deficiencies".

21 See T. P. Hill, *The Measurement of Real Product*, O.E.C.D., Paris, 1971, who concludes "Although the results are not completely conclusive they reinforce the general conclusion of this report that differences in growth rates observed between different countries' need to be interpeted with a great deal of caution".

Table 1

DENISON'S ESTIMATES OF THE GROWTH OF OUTPUT 1950-62
annual average percentage point contribution to growth rate

	Net national product at factor cost	Cyclical adjustment	Agricultural fluctuation adjustment	Measurement variation	Adjustment required to measure growth in U.S. prices
Belgium	3.20			−.17	−.11
Denmark	3.51	−.22	.07		−.23
France	4.92		.01	−.23	−.49
Germany	7.26				−.91
Italy	5.96		−.01		−.60
Netherlands	4.73	−.19	−.02		−.23
Norway	3.45		.02		−.12
United Kingdom	2.29	.09			−.09
United States	3.32	.04			.00

Table 2

ALTERNATE ESTIMATE OF THE GROWTH OF OUTPUT 1950-62
annual average percentage point contribution to growth rate

	Gross national product at market prices	Cyclical adjustment	Agricultural fluctuation adjustment	Measurement variation	Adjustment required to measure growth in U.S. prices
Belgium	3.32			−.17	−.11
Denmark	3.73	−.22	.07		−.23
France	4.83		.01	−.23	−.49
Germany	7.29				−.91
Italy	6.01		−.01		−.60
Netherlands	4.53	−.19	−.02		−.23
Norway	3.71		.02		−.12
United Kingdom	2.64	.09			−.09
United States	3.41	.04			.00

demand and factor price ratios. Denison's procedure involves a "correction" for this by measuring output growth in U.S. rather than national prices. He does not have enough data to do this directly, but derives a proxy from the relationships between estimates at U.S. and European prices shown in the O.E.E.C. studies of Gilbert and Associates.[22]

It might be advisable to make further adjustments to correct for conventions inappropriate for growth analysis. Denison feels obliged to make a downward correction to his quality-adjusted labour input to allow for the fact that ouput in some sectors is measured by employment. The alternative would be to adjust output upwards by an appropriate amount. One might deduct the impact of foreign investment and deal with domestic rather than national product as Jorgenson and Griliches do. One might treat some government services as intermediate rather than final product.

In contrast with Denison, Jorgenson and associates narrow the scope of the inquiry by deducting government activity from output and inputs.[23] This is a fairly common American practice but it introduces an element of unrealism in economies where government is not only very important, but is constantly growing in influence. It is also inconsistent because government activity in education does figure importantly in their model. My own feeling is that the scope of the inquiry should be wide enough to encompass all significant sources of growth.

In recent years the usefulness of national accounts concepts and of growth accounting have come under fundamental attack from Galbraith and Mishan who have argued that the whole business is a waste of time because G.N.P. figures have no welfare significance. Galbraith argues that a large part of consumer demand is artificially stimulated by advertising. He makes a sharp distinction between

22 See A. Maddison, "Comparative Productivity Levels in the Developed Countries", this *Review*, December 1967 for a detailed explanation of the point at issue. The impact of using U.S. rather than national weights is analogous to the downward bias usually involved in the use of current year weights as distinct from base year weights in index numbers for one country. Although I have used Denison's correction factors in my alternate estimates, I have some doubts about the validity of this correction procedure in a study where most magnitudes are measured in national prices.

23 They also make some other adjustments which are not too significant in their controversies with Denison, e.g. they treat consumer durables as a capital good, they have a valuation system which is neither factor cost nor market price, and they use Divisia index numbers.

private and public goods, and argues that needs for the former have been virtually satiated.[24] His other main argument is that economic growth has created unmeasured and very serious disamenities such as pollution and urban crowing. In any proper balance sheet these evils should figure as a negative item in the growth accounts. Mishan's argument relies on the same two basic points as Galbraith: (a) the synthetic nature of "demand"; (b) the existence of external diseconomies. The main difference is that Mishan's policy recommendations are too extreme to be taken seriously, and he does not share Galbraith's penchant for public goods.[25] His ideal world is a Walter Mitty phantasy peopled by characters with the aesthetic sensitivity of Shelley and bankbooks like J. P. Morgan who yacht around the Mediterranean greeted at every anchorage by unspoiled rustics.

Galbraith's first point has some relevance in the U.S.A. where T.V. advertisers are permitted to inflict themselves *ad libitum* on the long-suffering public, and where political shibboleths have held back the development of necessary forms of public expenditure. But there has been a big upsurge in government spending in the U.S.A. and Europe since Galbraith wrote. Governments spend large amounts on items like Concorde and men on the moon, which are more costly aberrations than tailfins on Cadillacs. Galbraith's fundamental point about affluence is as unrealistic as Mishan's. If ordinary people were as satiated with wordly goods as he suggests, it is curious that wage demands are so pressing, and that growing numbers of people risk imprisonment to rob trains and banks.

Galbraith and Mishan are lobbyists writing to attract maximum attention. Both exaggerate, and neither makes a sober attempt to quantify the negative externalities they decry or to work out the cost of their corrective policies. Tentative efforts so far made to measure costs of pollution do not suggest that it is a very big negative item, and there are some significant positive factors in the environmental

24 See J. K. Galbraith, *The Affluent Society*, Chapter 9.

25 See E. J. Mishan, *The Costs of Economic Growth*, Staples Press, London, 1967. See W. Beckerman, "The Desirability of Economic Growth", in N. Kaldor, *Conflicts in Policy Objectives*, Blackwell, Oxford, 1971 for a comment on Mishan. More recently there has been another doomsday book on growth more extreme than Mishan, by D. L. Meadows and Associates, *The Limits to Economic Growth*, Potomac, New York, 1972, which revamps Malthus with the help of a computer.

scene. Air and water pollution have fallen sharply in the U.K.,[26] and Paris has been transformed by *ravalement*. The quality of life has improved in other ways not measured in national accounts. Consumer choice has been widened by the development of international trade, there is a lower incidence of industrial disease, offices and factories have been improved, and people are less worried about unemployment than they were in the 1930s. We are not really in a position to judge whether on balance the externalities have been positive or negative. Furthermore some "quality of life" problems, such as crime, violence and drug addiction have no obvious link with economic growth.

However, Galbraith and Mishan have raised matters of obvious public concern and growth accounting must take some heed of them. The point about externalities is not new but was discussed *in extenso* by Pigou half a century ago.[27] Pigou was also interested in income distribution, an aspect of welfare not much discussed by Galbraith and Mishan. Thirty years ago, Kuznets advanced a concept of output smaller than that currently used because he deducted some items as regrettables and instrumentals which are now treated as final goods.[28] In the debate on this issue in the 1940s, he was accused of injecting a Ruskinian "moralistic flavor" into national income measurement and he lost out to the group of economists who made the official estimates in the U.S. Department of Commerce (one of whom was Denison).[29] There may now be a case for modifying our concept of total output to bring it closer to what Kuznets originally suggested.

Recently W. Nordhaus and J. Tobin[30] have produced a "measure of economic welfare" (M.E.W.) and related it to the

26 See Royal Commission on Environmental Pollution, *Final Report*, Cmnd. 4585, H.M.S.O., London, February 1971.

27 See A. C. Pigou, *The Economics of Welfare*, Macmillan, London, 1920.

28 Kuznets' estimates are compared with the official (Department of Commerce) estimates for the U.S. in Kendrick's book, *op. cit.*

29 See S. Kuznets, "Discussion of the New Department of Commercial Income Series, National Income: A New Version", *Review of Economics and Statistics*, August 1948 and the reply in the same issue by M. Gilbert, G. Jaszi, E. F. Denison and C. F. Schwartz, "Objectives of National Income Measurement: A Reply to Professor Kuznets". Denison's position is basically the same as in 1948, see E. F. Denison, "Welfare Measurement and the G.N.P.", *Survey of Current Business*, January 1971.

30 See W. Nordhaus and J. Tobin, "Is Growth Obsolete?" paper presented to the Conference on the Measurement of Economic and Social Performance, N.B.E.R., Princeton, November 1971. For an earlier and more flimsy attempt to measure welfare which includes

wider framework of traditional national income accounts. They deduct certain items from private and government consumption which they consider to be either regrettable or intermediate products. They deduct expenditures on consumer durables but impute a flow of income from the stock of consumer durable goods and from government assets, which are not included in the present national accounting framework. They add an imputation for the value of leisure (with three variant measures) and the value of non-market labour activity, and they deduct the value of disamenities caused by urbanisation, etc. They end up with variant measures of M.E.W. which are much bigger than G.N.P. in absolute terms but have lower growth rates. These estimates are still under active discussion and may well affect future approaches to growth accounting. For the present, however, we shall continue to use the traditional G.N.P. measures, with the minor modifications already mentioned.

III. Capital Inputs

In measuring capital inputs, Denison faced considerable practical and theoretical difficulties. One of the major problems is that official capital stock figures are not available for all countries and international agencies have as yet done little to make them comparable.

Official estimates for Germany, the U.K. and U.S.A. have appeared since Denison wrote his book,[31] but he was obliged to use figures based on widely different methods and coverage. For some countries (Denmark, Italy, Norway and the Netherlands) only net stock figures were available and the gross stock had to be inferred; elsewhere, substantial adjustment was needed to get the coverage he wanted. He used an average of gross and net capital stock growth rates, though (somewhat inconsistently) he calculates capital's share of income after excluding all depreciation.

an allowance for improved quality of goods, see A. W. Sametz, "Production of Goods and Services: The Measurement of Economic Growth", in E. G. Sheldon and W. E. Moore, *Indicators of Social Change*, Russell Sage, New York, 1968.

31 See H. Lützel, "Das reproduzierbare Anlagevermögen in Preisen von 1962", *Wirtschaft und Statistik*, October 1971, Statistisches Bundsamt, Wiesbaden; *National Income and Expenditure 1971*, C.S.O., London; L. Grose, I. Rottenberg and R. C. Wasson, "New Estimates of Fixed Business Capital in the United States, 1925-65", *Survey of Current Business*, 1966. See L. Nesterov, "Current Position of National Wealth Estimation in the World", *Review of Income and Wealth*, September 1969 for a review of existing estimates in 53 countries.

My own preference is for the gross stock figure, because the physical production capacity of capital does not deteriorate much, and depreciation in the value of capital reflects the discount due to its declining life expectation rather than physical deterioration. I also include government capital, which has an important though indirect impact on growth potential, but which Denison excludes. Finally I include an embodiment effect (à la Solow but of smaller magnitude), which makes capital's explanatory role in growth bigger than in Denison's reasoning.

Denison divides capital into several categories, business plant and equipment, housing, inventories, foreign capital, government capital (which he ignores), and land. It is the first of these categories which is the most important and interesting in economic growth. The impact on growth of each component of Denison's capital measure is shown in Table 3.

Enterprise Plant and Equipment

His estimates for enterprise plant and equipment are shown in Table 4. They can be viewed as the result of three components: (a) the size of the initial stock of capital in 1950 (which must be subject to substantial error in view of our rather limited knowledge capital formation, war damage, lives of assets, etc. in the 30 years or so before 1950); (b) the amount of capital formation between mid-1950 and mid-1962; (c) the amount of capital scrapped from mid-1950 to mid-1962.

The results are rather sensitive to errors in the estimate of the initial capital stock in 1950. It can be seen in column 1 of Table 4 that Denison's preferred estimate of the 1950 capital stock in the U.S.A. is well below that in any European country (in relation to output),[32] and the estimate for Norway is very high. It may be that these differences are an accurate representation of reality, but there is room for considerable scepticism on this point. If the estimates were all built up by the perpetual inventory method and there were good data on capital formation for a few decades and good price indices, the figures would be reasonably comparable only if the basic procedures in relation to the assumed life of assets, retirement patterns (i.e. distribution of service lives around the mean life),

32 I have shown the figures in relation to G.N.P. whereas Denison's output concept is national income, but this does not affect the argument.

TABLE 3

COMPONENTS OF DENISON'S ESTIMATE OF THE IMPACT OF CAPITAL ON INCOME GROWTH 1950-62

annual percentage point contribution to growth

	Total	Business Plant and Equipment			Other Capital			
		Increase in Stock of Business Plant & Equipment	Change in Use of Capacity	Reduction in Average Age of Plant & Equipment	Dwellings	International Assets	Inventories	Land
Belgium	0.41	.39	.00	.00	.02	−.06	.06	.00
Denmark	0.99	.65	.00	.04	.13	.02	.15	.00
France	0.78	.55	.00	.00	.02	.02	.19	.00
Germany	1.69	1.00	.26	.04	.14	−.08	.33	.00
Italy	0.69	.53	.00	.00	.07	−.03	.12	.00
Netherlands	1.03	.65	.00	.00	.06	.10	.22	.00
Norway	0.93	.79	.00	.04	.04	−.07	.13	.00
United Kingdom	0.51	.43	.00	.00	.04	−.05	.09	.00
United States	0.83	.43	.00	.00	.25	.05	.10	.00

Source: E. F. DENISON, *op. cit.*

TABLE 4

DENISON'S ESTIMATES OF THE GROSS AND NET STOCK OF ENTERPRISE STRUCTURES AND EQUIPMENT IN 1950 AND 1962

	Gross stock in 1950 in relation to 1950 G.N.P. (1950 G.N.P. =100)	Gross stock in 1962 in relation to 1950 G.N.P. (1950 G.N.P. =100)	Growth rate of gross stock 1950-62	Net stock in 1950 in relation to 1950 G.N.P. (1950 G.N.P. =100)	Net stock in 1962 in relation to 1950 G.N.P. (1950 G.N.P. =100)	Growth rate of net stock 1950-62	Average growth rate of gross and net stocks 1950-62
Belgium	207	293.1	2.9	116	163.8	2.9	2.92
Denmark	(173)	(303.3)	(4.8)	94	189.1	6.0	5.38
France	199	305.6	3.6	105	175.5	4.3	3.99
Germany	233	441.5	5.5	133	295.8	6.9	6.17
Italy (a)	(229)	(349.9)	(3.6)	125	198.7	4.0	3.78
Netherlands	(263)	(431.1)	(4.2)	143	256.7	5.0	4.60
Norway	(344)	(566.2)	(4.2)	187	338.5	5.1	4.65
United Kingdom	199	284.1	3.0	103	168.0	4.2	3.58
United States	140	216.8	3.7	75	117.5	3.8	3.74

(a) Excludes agriculture.

Source: The basic data are all from E. F. DENISON, *Why Growth Rates Differ*, but columns 1, 2, 4 and 5 are expressed in relation to 1950 G.N.P. on the basis of G.N.P. figures published by O.E.C.D.

depreciation rates (in the case of estimates of net stock) or degree of detail in the classification of assets were similar. In fact, there were big differences in these respects between the estimates used by Denison. The European estimates are based on service lives much longer than those assumed for the U.S.A.[33] This is a major reason why the European capital-output ratios in 1950 were above those in the U.S.A. Apart from this, there are other likely sources of error, such as the fact that Norwegian estimates of capital formation (and of capital stock) tend to be bigger than those elsewhere because Norwegian statisticians treat repair and maintenance as capital formation, and Denison has not adjusted for this.

In appendix A, I have made crude estimates of capital formation between 1920 and 1962 in seven countries in order to get a rough crosscheck on Denison's figures. I have assumed that all assets have a life of exactly 30 years. I have made an allowance for war damage. My figures include government capital whereas Denison's do not. By cumulating capital formation from mid-1920 to mid-1950, I arrived at the figures for capital stock in 1950 which are shown in Table 5 compared with Denison's. The individual country figures differ a good deal in some cases, but the average for the seven countries is not much different from Denison's. Given the crudeness of the estimates, I feel it is safer to assume that the 1950 ratio of capital to output was the same in all countries, rather than use either his crude figures or mine.

TABLE 5

GROSS NON-RESIDENTIAL FIXED CAPITAL STOCK IN 1950 IN RELATION TO G.N.P.

	Maddison (Includes general government capital)	Denison (Excludes general government capital)
Denmark	189	173
France	236	199
Germany	193	233
Italy	272	229
Norway	253	344
U.K.	141	199
U.S.A.	195	140

Source: Maddison derived from Appendix A, Denison from Table 4 above.

33 DENISON, *op. cit.*, p. 425 gives figures which suggest that German and British assumed service lives are twice as long as in the U.S.A. for equipment.

The second problem is the accuracy of the estimate for capital formation in the period 1950-62. Denison used a variety of national sources with big differences in estimating procedure. In Germany, for instance, the procedure seems to assume changes in the average life of assets.[34] This may be perfectly valid, but will distort the comparison if a similar assumption is not made for the other countries. In view of these problems, I made my own simple estimates of capital formation (and discards) from 1950 to 1962 as shown in Table 6. Government assets are included. My procedure is crude because it has no breakdown by type of asset, it assumes that all assets have a 30-year life (with no variation in the retirement pattern) and that there is no deterioration in assets before they are scrapped. I assumed that a third of the 1950 assets were discarded from mid-1950 to mid-1962 (this is the average relation, for the seven countries with data, of the proportion of 1920-32 investment to 1920-50 investment). However, it has the advantage that the procedures are completely explicit and comparable.

TABLE 6

ALTERNATE ESTIMATE OF THE GROWTH OF GROSS CAPITAL STOCK 1950 TO MID 1962

	Alternate estimate of gross capital stock in 1950 (including government capital) as percent of 1950 G.N.P.	Gross increment to capital stock mid 1950 to mid 1962 as percent of 1950 G.N.P.	Assumed discards from 1950 stock mid-1950 to mid-1962 (=.33 of 1950 stock)	Estimated 1962 gross capital stock as percent of 1950 G.N.P.	Growth rate of gross capital stock mid-1950 to mid-1962
Belgium	210	185.4	69.3	326.1	3.7
Denmark	210	209.0	69.3	349.7	4.3
France	210	225.2	69.3	365.9	4.7
Germany	210	343.8	69.3	484.5	7.2
Italy	210	261.2	69.3	401.9	5.6
Netherlands	210	296.0	69.3	436.7	6.3
Norway	210	327.5	69.3	468.2	6.9
U.K.	210	166.2	69.3	306.9	3.2
U.S.A.	210	197.5	69.3	338.2	4.0

Source: See Appendix A.

34 I am not sure of this, as Denison used unpublished estimates of Kirner, to which I have not had access. But Kirner's later published figures did assume a change in the life of assets, see W. KIRNER, *Zeitreihen für das Anlagevermögen der Wirtschaftsbereiche in der Bundesrepublik Deutschland*, D.I.W., Berlin, 1968.

The estimates are summarised in Table 6. The first column represents non-residential gross fixed capital stock (including government investment) in 1950. The second shows cumulated investment from mid-1950 to mid-1962. The third entry is a crude estimate of the assumed discards (i.e. the capital of mid-1920 to mid-1932). The difference between my estimates and Denison's can be seen by comparing Tables 4 and 6. For the U.K. and U.S.A. the figures for growth in gross capital stock are similar, but for all the other countries except Denmark, my figures are higher. The average for the nine countries is 5.1 per cent annual growth compared with Denison's 3.9 per cent for gross stock (and the 4.3 per cent average for gross and net stock which he used).

Age of Capital and the Rate of Embodied Technical Progress

Denison makes no general adjustment for differences in vintages of capital, and assumes that virtually all technical progress is disembodied. He does not reject the embodiment hypothesis in principle, and incorporates a partial vintage improvement in countries where he believes that there was a change in the average age[35] of the capital stock, i.e. Denmark, Germany and Norway. To me, this seems inconsistent. Once one admits that the quality of capital is affected by its age, one has accepted the essence of the Solow-Salter vintage argument, and it would seem logical to include the whole impact of the embodiment effect.

In any case, I think Denison is wrong in assuming that the change in average age was important only in Denmark, Germany and Norway. He made this assumption by comparing rates of capital formation in 1950-62, whereas he needed longer-run historical evidence to justify such a conclusion. My own calculations suggest that the change in age structure was bigger in France, Italy and the United States than it was in Denmark and it was bigger in France than it was in Germany (see Table 7).

Although I disagree with Denison's partial embodiment procedure, I think his suggested 2 per cent rate of embodiment is reasonable. He argues that the upper limit on the rate of embodied technical progress can be inferred from the average service lives of

35 He defines change in average age in narrow sense, i.e. after eliminating changes in the distribution of capital between buildings and equipment.

TABLE 7

CHANGE IN THE AVERAGE AGE OF THE NON-RESIDENTIAL FIXED CAPITAL STOCK 1950-62

	1950 Average Age in years	1962 Average Age in years
Denmark	13.2	11.0
France	14.7	11.1
Germany	13.6	10.1
Italy	14.3	11.5
Norway	12.1	10.3
U.K.	12.6	10.7
U.S.A.	13.7	11.1

Source: derived from Appendix A (figures for Belgium and the Netherlands were not available).

capital goods[36] which leads him to reject the higher rates of embodied progress which Solow had suggested.

Table 8 shows the result of embodying Denison's 2 per cent rate of technical progress, assuming that progress proceeded at the same rate over the whole period 1920-62. The result is shown in the last column of Table 8 which rises a good deal faster than the last column of Table 6, i.e. by an average of 7.7 per cent a year instead of 5.1 per cent.

Table 9 shows my final adjustment to Denison's figures. I have tried to explain growth of G.N.P. by showing movements in gross capital stock, and I use the share of capital in G.N.P. as a weight. He explains growth of national income, shows the movement in the weighted average of gross and net capital stock, and uses the share of capital in national income as a weight. The other difference is that I include government capital, have added an imputation of income from government capital to G.N.P., and expressed the share of capital (including government capital) in this augmented G.N.P. As a result, I give a weight to capital formation which is much bigger than Denison does (compare second and first columns of Table 9).

36 If technical progress is embodied, replacement will take place largely because of obsolescence, and will occur when operating costs of old equipment exceed the cost of new equipment to replace it.

TABLE 8

ALTERNATE ESTIMATES OF THE GROWTH OF GROSS CAPITAL STOCK 1950-62 ASSUMING 2 PER CENT EXPONENTIAL EMBODIED TECHNICAL PROGRESS

	Alternate estimate of quality adjusted gross capital stock in 1950 including government capital as percent of 1950 G.N.P.	Gross increment to quality adjusted capital stock mid-1950 to mid-1962 as percent of 1950 G.N.P.	Assumed discards from 1950 quality adjusted capital stock from mid 1950 to mid 1962 (=1/4 of 1950 stock)	Estimated 1962 quality adjusted capital stock as percent of 1950 G.N.P.	Growth rate of gross capital stock mid 1950 to mid 1962
Belgium	163	212.1	40.8	334.3	6.2
Denmark	163	239.5	40.8	361.7	6.9
France	163	258.4	40.8	380.6	7.3
Germany	163	389.8	40.8	512.0	10.0
Italy	163	299.7	40.8	421.9	8.2
Netherlands	163	339.4	40.8	461.6	9.1
Norway	163	374.2	40.8	496.4	9.7
U.K.	163	190.3	40.8	312.5	5.6
U.S.A.	163	224.0	40.8	346.2	6.5

Source: First column is the average figure for mid-1950 capital stock based on cumulation of fifth column of Appendix A for seven countries for mid-1920 to mid-1950 and an allowance for war damage. See Appendix A. Third column is based on assumption that discards amounted to a quarter of the 1950 capital stock' (this is the average ratio of the 1920-32 capital increments to the 1950 stock derived from Appendix A).

The net result of these modifications is to give capital a considerably higher weight in explaining economic growth than does Denison, as is apparent from Table 9. Our alternate estimate of the impact of capital "explains" three times as much growth on average for the nine countries as Denison's.

Use of Capacity

There are other aspects of capital measurement worth consideration. Jorgenson and Griliches stress the importance of variations in capacity use. Denison considers their procedure defective and rejects their adjustment for the U.S.A. (correctly, I think). In *Why Growth Rates Differ*, he makes a capacity adjustment only for Germany. This is not a normal capacity adjustment, but reflects the boost to

TABLE 9

ESTIMATES OF THE CONTRIBUTION OF ENTERPRISE PLANT AND EQUIPMENT AND OF NON-RESIDENTIAL FIXED CAPITAL FORMATION TO ECONOMIC GROWTH 1950-62

	Enterprise Plant and Eqcipment percentage share of national income average of all years 1950-62	Non-Residential Fixed Capital Formation's Percentage Share of Augmented G.N.P. average of all years 1950-62	Denison's estimate of Capital Stock Growth Rate (average of gross and net) (enterprise structures and equipment)	Alternate estimate of gross Capital Stock Growth Rate (non-residential structures & equipment) assuming 2 percent exponential embodied technical progress	Denison's estimate of annual percentage point contribution of enterprise capital to growth	Alternate estimate of percentage Point contribution of Non-Residential Fixed Capital to Growth assuming 2 percent Exponential Embodied Technical Progress
Belgium	13.2	25.1	2.9	6.2	.39	1.56
Denmark	12.2	20.5	5.4	6.9	.65	1.41
France	13.8	24.2	4.0	7.3	.55	1.77
Germany	16.2	26.4	6.2	10.0	1.00	2.64
Italy	14.1	23.8	3.8	8.2	.53	1.95
Netherlands	14.2	24.4	4.6	9.1	.65	2.22
Norway	16.4	28.4	4.7	9.7	.78	2.75
U.K.	11.9	20.5	3.6	5.6	.43	1.15
U.S.A.	11.2	20.8	3.7	6.5	.43	1.35

Source: Column 1 is from DENISON, *op. cit.*, p. 38. Column 3 is from DENISON, *op. cit.*, p. 190. Column 5 is from DENISON, *op. cit.*, p. 140. In column 2, depreciation has been added to both numerator and denominator. Depreciation on enterprise plant and equipment is assumed to be equal to 80 per cent of depreciation as recorded in O.E.C.D. National Accounts Statistics for 1950-62. The numerator of column 2 was further adjusted upwards by 20 per cent to allow for imputed rentals on government capital, and the relevant amount (about 4 per cent of G.N.P.) is added to the denominator. Column 4 is taken from Table 8.

capacity derived from reactivation of war damaged plant and equipment. The procedure seems reasonable, but I would add .50 points a year to growth instead of Denison's .26 because the capacity item (like other capital inputs) gets a higher weight in my accounting. I have assumed an equal but opposite effect in Norway where a good deal of investment in the 1950s added little to output until the 1960s.[37]

37 See O.E.C.D. Economic Survey, *Norway* Paris, January 1972, p. 10.

Other Possible Adjustments to the Measure of Non-Residential Fixed Capital

There are other possible adjustments to the measure of capital stock which are worth further exploration. It would be useful to break down the vintage effect separately for construction and for machinery and equipment. As the structure of capital formation changes over time and between countries, this would have quite an impact on the estimates. Furthermore, we need to deepen the study of the forces which determine the rate of technical progress. The rate of technical progress may be higher now than in prewar years, which means that the accelerated rate of capital formation in Europe has had an even bigger impact on growth than we have shown. There are a number of different theories on what determines the rate of progress. Schumpeter's theory was one of spontaneous waves of innovation, others make technical progress a function of time and Kaldor [38] argues that technical progress is influenced by the rate of investment itself. I think Kaldor is right but the relationship probably applies on a world level, so that for any given country, unless it is a giant like the U.S.A., the rate of progress would appear to be a function of time rather than of the rate of investment. Increased spending on research and development and the increased stock of educated people may also have speeded up progress. In spite of all these positive influences, the realised rate of technical progress may be not very different from that in prewar years, because we are operating at much higher levels of capital formation. All of these activities may have simply served to offset the diminishing returns which one might normally have expected at the very high postwar levels of capital formation.

Other Types of Capital

Denison's measures of the impact of inventories and foreign investment do not call for methodological comment here. The only change I have made is to calculate these items in terms of their contribution to G.N.P. instead of to national income.

38 See N. KALDOR and J. A. MIRRLEES, "A New Model of Economic Growth", *Review of Economic Studies*, June 1962.

IV. Labour Input

The component elements of Denison's estimate of labour's contribution to growth are shown in Table 10. The biggest items are the rise in employment and in education. The other elements are the adjustment for hours, for work intensity, changes in age-sex composition and the adjustment to input to allow for the fact that output is measured by proxy employment indicators. Denison multiplies the first six components of Table 10 by column 7 to show their net contribution to income, which is shown in column 8.

Employment

Denison's employment estimates are derived from the O.E.C.D. publication, *Manpower Statistics*, which presents data in more comparable form than is available anywhere else. However, no figures were available for 1950 for Italy and France, for which Denison had to make his own guess. In the case of Italy, my guess for 1950 is considerably different from his. Table 11 compares Denison's employment figures with my alternate estimates which are based on later data.

Annual Hours per Employee

Denison's adjustment for changes in annual working hours per employee reflects the net effect of changes in weekly working hours, holidays, absenteeism because of strikes, sickness, and bad weather. As the information on hours is rather shaky and Denison's procedure is not completely explicit I preferred to substitute my own estimates for Denison's in the case of France, Germany and Italy.

Work Intensity

Denison asserts that there is a compensatory increase in work intensity which partially offsets declines in working hours. He assumes that above 2,529 hours a year, reductions in work time are fully compensated by increased work intensity, and below 1,762 hours a year there is no offset. In between, there is a varying and partial offset.

Denison first presented this compensatory formula in *The Sources of Economic Growth* in 1962, and by virtue of frequent

TABLE 10

COMPONENTS OF DENISON'S CALCULATION OF THE CONTRIBUTION OF LABOUR TO OUTPUT 1950-62

	Growth rate of employment	Intensity of labour effort	Change in average annual hours per employee	Impact of change in age-sex composition on labour quality	Impact of education on labour quality	Adjustment to allow for measurement of output by employment indicators	Share of labour in national income	Total annual percentage point contribution of labour input to growth
Belgium	.55	0.24	— .49	.14	.73	—.13	72.9	0.76
Denmark	.93	0.24	— .53	—.11	.22	.03	75.2	0.59
France	.11	0.02	— .06	.16	.46	—.11	77.0	0.45
Germany	2.00	0.58	—1.02	.06	.19	.03	73.7	1.37
Italy	.56	0.28	— .37	.16	.69	—.01	72.0	0.96
Netherlands	1.05	0.16	— .42	.01	.40	—.03	74.0	0.87
Norway	.18	0.19	— .44	—.11	.41	—.01	74.1	0.15
U.K.	.65	0.07	— .30	—.06	.45	—.03	77.8	0.60
U.S.A.	1.14	0.02	— .27	—.15	.73	—.05	78.6	1.12

Source: Column 1 from DENISON, *op. cit.*, p. 190; column 2, p. 66; columns 2-5 from p. 190 blown up by the proportions shown on p. 188 (Table 15-1 column 3); column 6 is the difference between the total of columns 2-5 as shown here and the total of the same columns as shown by Denison on p. 190; column 7 is from DENISON, *op. cit.*, p. 38.

EMPLOYMENT IN 1950 AND 1962 TABLE 11

	Denison's Estimates 000s		Alternate Estimates 000s		Estimates Compared 1950-62 (1950=100)	
	1950	1962	1950	1962	Denison	Alternate
Belgium	3,371	3,598	3,371	3,641	106.7	108.0
Denmark	1,978	2,210	1,980	2,210	111.7	111.6
France	(19,248)	19,507	(19,006)	19,622	101.3	103.2
Germany (F.R.+W.B.)	21,106	26,783	21,080	26,783	126.9	127.1
Italy	(18,868)	20,189	(16,985)	20,189	107.0	118.9
Netherlands	3,785	4,290	3,835	4,328	113.3	112.9
Norway	1,468	1,499	1,455	1,463	102.1	100.5
United Kingdom	(23,269)	25,148	23,229	25,214	108.1	108.5
United States	61,669	70,673	61,669	70,673	114.6	114.6

Sources: For 1950 both estimates are based on national sources and O.E.C.D., *Manpower Statistics 1950-62*, Paris 196. The latter is incomplete in some respects and the figures for Italy and France had to be estimated. The alternate estimates shown are the estimates I made when I wrote *Economic Growth in the West*. They are significantly different only for Italy. Denison's figures for 1950 are taken from DENISON, *op. cit.*, p. 46 adjusted upwards for Germany to include the Saar and W. Berlin, for the United States to include Hawaii and Alaska (p. 52). The figures in brackets indicate where estimates were made. For 1962 Denison took his figures from O.E.C.D., *Manpower Statistics 1954-64*; the alternate estimates are from the 1958-69 edition. The differences are not significant. In the case of the United States Denison uses a different series from O.E.C.D. which shows a higher level of employment but a similar trend and I have used the same figures as Denison. For 1962 for Denmark O.E.C.D. does not give a figure and I have used Denison's.

repetition, it is now accepted in many places as axiomatic. But in historical perspective the idea seems implausible. In 1870, the working year was about 3,200 hours in the countries considered.[39] The alleged change in work intensity from 1870 to the level at which he postulates disappearance of the phenomenon amounts to more than 50 per cent. It seems extremely unlikely that work habits have changed in this way. As people get used to longer holidays, a two day break at weekends and shorter weekly hours, the familiarity with leisure may well induce more leisurely work practices. Certainly a much bigger section of the population is able to take tea and coffee breaks, or use the office telephone for personal business than was the case a century ago, and most of them are less scared of foremen and overseers than were their grandfathers.

In the short term, a cut in working hours with no corresponding wage reduction may stimulate managerial efficiency, and workers may even be persuaded to work harder. But these effects wear off. Most of the labour force today have no recollection of a 50 or 60 hour work week and managers are not always on their toes. The major compensatory result of the reduction in working hours on labour input in the long term has probably been a reduction in fatigue and an increase in life expectation. But these effects figure elsewhere in the account. I therefore reject the notion that there is any long-term functional relation between working hours and work intensity. I simply assume that cuts in working hours lead to an equiproportionate cut in labour input.

However, there may be substantial variations in work intensity between countries for socio-cultural, climatic or nutritional reasons, and variations over time due to changes in the degree of competition and national aspirations. Denison himself has remarked that work intensity has an importance beyond that which he has quantified.[40] Leibenstein argues that most economies normally work with a certain amount of slack rather than at the boundary of their production potential, both in terms of labour and managerial effort.[41] If

39 See A. MADDISON, *Economic Gowth in the West*, Appendix G.

40 See his contribution to R.E. CAVES, ed., *Britain's Economic Prospects*, Allen and Unwin, London, 1968.

41 See H. LEIBENSTEIN, "Allocative Efficiency vs. 'X-efficiency'", *American Economic Review*, June 1966, and "Organisational or Frictional Equilibria, X-Efficiency, and the Rate of Innovation", *Quarterly Journal of Economics*, November 1969.

this slack were only half of what Denison postulates, e.g. if work and managerial intensity are "normally" expandable by 25 per cent, then measures which sharply increase competition (e.g. tariff reduction) may produce an unexpectedly large output bonus by mobilising this idle potential.[42] Similarly, we may assume that Germans worked harder than most people in the 1950s because they wanted to restore previous living standards and rebuild their assets. In the 1960s, they may have worked less hard. Unfortunately, there is no real evidence for judging the importance of this phenomenon.

Age and Sex

Denison adjusts for differences in quality of labour because of changes in employment by sex and age, using relative wage rates as adjustment factors. This seems reasonable, though wage differentials between sexes are influenced by legislative and institutional factors as well as productivity differences, and there are substantial fringe benefits which appear to be excluded from Denison's weighting procedure. There are also differences between countries in the measurement of family workers, female and part-time labour, particularly in agriculture.[43] Nevertheless we have accepted Denison's adjustment for this item.

Measurement Conventions

Denison felt he had to adjust his qualitative changes in labour supply downwards because of the national accounting convention of using changes in employment (unadjusted for quality) in some sectors as a proxy measure for changes in output. The adjustment is both crude and small; I do not think it is worth making.

42 See H. Myint, "The Classical Theory of International Trade and the Underdeveloped Countries", *Economic Journal*, June 1958, who made a similar point about the initial impact of international trade in South East Asia. Myint appeared to be dealing with a special case, but it may simply have been an extreme example of a general case.

43 See my discussion of this point in "Comparative Productivity Levels in the Developed Countries", this *Review*, December 1967.

Education

Denison's major adjustment for labour quality is for formal education. He divides the labour force into up to ten groups according to length of education.[44] Each group is given a weight based on empirical evidence of its apparent earning power. The observed range of variation in income between people with no education and those with four years of college is about 1 : 4.7 in the U.S.A. Denison reduces the variation by 40 per cent to discount for variations in income due to differences in intelligence and social background. In general, he measures the length of education in years, but for the U.K. and U.S.A. he adjusts for increase in attendance rates and in effect measures education in days. I think this is misleading because there were probably similar changes in several other countries. I have therefore offset his adjustment in my alternate estimate.

Griliches has argued against Denison's 40 per cent downward adjustment for the following reasons.[45] Ability in its economically useful form is itself largely the product of learning. The genetic pool has never shown signs of running dry, and intelligence has not been a scarce resource constraining economic growth. If it had been, the average quality of graduates would have declined as they grew in number relative to the total population, but there is no evidence of decline in academic achievement or in incomes of graduates. On Denison's other point, parental influence, Griliches argues that it operates mainly via education — the willingness and ability to bear direct costs or to sacrifice student earnings foregone. In any case the parental characteristic most influential in academic achievement is parental education: thus Griliches concludes that no downward adjustment should be made for ability and parental education.

Denison's adjustment is confined to formal education and does not include items such as on-the-job training. Much less is known about this than about formal education, but Denison argues and

44 Denison assumes that the quality of a year of education in one country is as good as that elsewhere. The point is not important in considering trend movements but it is interesting to note the results of an international study of school achievement which suggests significant national differences. See T. Husén, ed., *International Study of Achievement in Mathematics*, vol. II, Wiley, New York, 1967, pp. 22-25. At all levels, U.S. students scored below average in this 12-country study.

45 See Z. Griliches, "Notes on the Role of Education in Production Functions and Growth Accounting", in W.L. Hansen, ed., *Education, Income and Human Capital*, N.B.E.R., Columbia University Press, New York, 1970.

proves that organised on-the-job training schemes are much less important than formal education. However, if we define on-the-job training to include learning from experience it becomes much more important. Mincer has inferred the magnitude of these two items in the U.S.A. from information on earnings foregone. He assumes that the degree to which younger workers earn less than older ones reflects indirect payments they make to firms for training and the acquisition of experience. He estimates that the two items combined are about as important as formal education.[46] If the state of knowledge were not increasing and the labour force were static, the net

TABLE 12

ALTERNATE ESTIMATES OF THE CONTRIBUTION OF LABOUR TO OUTPUT 1950-62

	Growth rate of employment	Change in average annual hours per employee	Impact of change in age-sex composition on labour quality	Impact of education on labour quality	Share of labour in augmented G.N.P.	Alternate estimate of labour's annual percentage point contribution to growth
Belgium	0.64	−.49	.14	1.22	63.1	.95
Denmark	0.92	−.53	−.11	.37	66.7	.43
France	0.27	.11	.16	.77	65.8	.86
Germany	2.02	−.70	.06	.32	63.1	1.07
Italy	1.45	−.03	.16	1.15	62.3	1.70
Netherlands	1.01	−.42	.01	.67	63.4	.81
Norway	0.05	−.44	−.11	.68	61.2	.11
United Kingdom	0.69	−.30	−.06	.63	68.6	.66
United States	1.14	−.27	−.15	.80	68.4	.84

Source: First column is from Table 11 above. Second column from Denison, p. 66 (column 12 of his Table 6-6 divided by column 6), except for France, Germany and Italy where I used the sources cited in my book, *Economic Growth in the West*, Appendix G. Third column is from Denison (see my table 10 above). Fourth column is Denison's education adjustment blown up by two thirds (in the case of the U.K. and U.S.A. I have removed Denison's adjustment for increased school attendance). Fifth column is derived by the procedures described in my Table 9 above.

46 See J. MINCER, "On-the-job Training: Costs, Returns and Some Implications", *Journal of Political Economy*, October, 1962.

amount of learning from experience would be zero. Against the learning process there is offsetting obsolescence and loss of skill by older workers and in a static world this would fully offset new learning. However, the net contribution of learning from experience to growth is substantial when knowledge is increasing. It is in fact the counterpart of the embodiment effect assumed for capital.[47] Pending further empirical evidence, I have assumed that on-the-job training and learning from experience have a big enough effect to swing the balance in favour of Griliches procedures for assessing the impact of education. I have therefore blown up Denison's estimate of the contribution of education by two-thirds as a crude offset to his 40 per cent downward adjustment.

It seems likely that the supply of education is in excess of what the economy "requires" at any given level of output. Economic motivation is only one of the reasons for acquiring education; it is highly subsidised so that private returns are bigger than social returns, and there is a standby capacity of educated women and older people who can be attracted into work if incentives change. Hence, the relation of education to growth is a peculiarly subtle one. But the Denisonian approach is probably an approximation to the kind of forces which are operative, except in extreme cases (perhaps Germany in 1950) where the stock of education may be in such lavish supply that additions to the stock are less relevant than changes in its degree of utilisation.

V. Other Components of Growth

Denison explains "total factor productivity" in terms of four identified items and a residual. These are (a) benefits resulting from reduction of trade barriers; (b) economies of scale; (c) gains from reallocation of labour; and (d) technical progress.

Benefits from Trade Liberalisation

Denison's measure of the impact of trade liberalisation on growth is surprisingly small in view of the huge political effort involved in creating the Common Market and in securing tariff reductions in

47 In fact, the scope for learning from experience probably depends to a considerable extent on the rate of capital formation.

G.A.T.T. He is not the only author who gives a low weight to the contribution of trade liberalisation,[48] but I think he understates its importance.

For 1950-62[49] Denison estimates that reductions in trade barriers made the following contribution to growth.

TABLE 13

DENISON'S ESTIMATE OF THE CONTRIBUTION OF TRADE LIBERALISATION TO GROWTH

average annual percentage point contribution to growth of income

Belgium	0.16	Netherlands	0.16
Denmark	0.09	Norway	0.15
France	0.07	United Kingdom	0.02
Germany	0.10	United States	0.00
Italy	0.16		

He arrives at these estimates by assuming that cost differentials were two-thirds as high as tariff barriers, i.e. that domestic production behind a 15 per cent tariff wall would, on average, involve 10 per cent higher costs than free trade. The gain from trade is two-thirds of the tariff reduction multiplied by the increase in the trade ratios. He used estimates of nominal tariff levels, but it is preferable to use "effective" tariffs, which measure the net incidence of protection on value added, and therefore give a more accurate picture of possible cost differentials. As final goods get greater protection than raw materials, the "effective" rate is generally higher than the nominal one. Use of effective rather than nominal rates would probably raise

48 See *The Effects of E.F.T.A. on the Economies of Member States*, E.F.T.A., Geneva, 1969, and T. SCITOVSKY, *Economic Theory and Western European Integration*, Stanford, 1958. I have set out my own views in a paper included in C. P. KINDLEBERGER and A. SHONFIELD, eds., *North American and Western European Economic Policies*, Macmillan, London, 1971.

49 Denison does not calculate the gain for 1950-55 but assumes that its impact was at the same rate as in 1955-62 (which he does measure). In fact, it is likely that the gains were bigger from 1950-55 than in the latter period. The 1950-55 gains reflected the effect of other factors rather than the direct impact of trade according to Denison, p. 262. But here he strays into a discussion of ultimate rather than proximate causality which is equally applicable to other parts of his argument.

Denison's estimates by about threequarters.[50] Denison takes no account of quantitative restrictions which were important in 1950 and had largely disappeared for non-agricultural items by 1962 (see Table 14). The removal of these barriers had a big effect on the efficiency of resource allocation in the 1950s. So it would probably be safe to assume that the primary effect of reducing trade barriers was at least twice as large as Denison postulates.

TABLE 14

CHANGING INCIDENCE OF QUANTITATIVE RESTRICTIONS ON TRADE WITHIN EUROPE AND WITH THE DOLLAR AREA IN THE 1950s

	Percentage of intra-European trade subject to quota restrictions		Percentage of dollar area trade subject to quota restrictions	
	30 June 1950	30 June 1961	1 January 1953	1 May 1961
Belgium	44	3	43	6
Denmark	47	5	99	3
France	42	1	100	12
Germany	53	7	100	13
Italy	46	2	100	10
Netherlands	45	3	43	6
Norway	61	15	100	9
U.K.	43	3	93	7

Source: *Twelfth Annual Economic Review*, O.E.E.C., 1961.

Denison makes a substantial allowance for economies of scale, but does not allocate these to the sectors of the economy in which they originated. If we are to give trade its rightful importance in growth, we must allocate to it the scale effects for which it was responsible. We assume therefore that scale effects were distributed evenly over different categories of demand and we derive the estimate

50 See B. BALASSA, "Tariff Protection in Industrial Countries. An Evaluation", *Journal of Political Economy*, December 1965.

of scale economies arising from trade shown in Table 15. These gains are large and are biggest in the small countries where trade is most important.

TABLE 15

IMPACT OF SCALE ECONOMIES ON GAINS FROM TRADE 1950-62

	Output gains from economies of scale at the national level	Ratio of growth of exports to growth of G.N.P. in constant prices	Impact on output of scale economies arising from trade
Belgium	.165	61.2	.10
Denmark	.175	43.8	.08
France	.220	14.9	.03
Germany	.315	24.8	.08
Italy	.275	25.9	.07
Netherlands	.240	75.9	.18
Norway	.190	60.2	.11
U.K.	.110	20.8	.02
U.S.A.	.150	7.1	.01

In addition, trade liberalisation probably increased competition and the intensity of managerial effort (or X-efficiency as Leibenstein calls it). It is difficult to analyse the effects in any precise quantitative way. They are felt both directly via traded goods and indirectly via potential trade. Increased competition via international trade has also increased the area of consumer choice. However, we have not made any quantitative imputation of gains from this source.

Economies of Scale

Denison attaches major importance to economies of scale. There are two components: (a) economies at the national level; (b) economies in local markets.[51] The impact of these items is shown below:

51 Denison has a third item, economies of scale associated with income elasticities, which we have preferred to treat as a correction to measured growth (see Tables 1 and 2 above).

TABLE 16

DENISON'S MEASURE OF THE CONTRIBUTION OF ECONOMIES OF SCALE TO INCOME GROWTH

annual percentage point contribution

	Economies of scale at the national level	Economies of scale in local markets
Belgium	.33	.07
Denmark	.35	.07
France	.44	.07
Germany	.63	.07
Italy	.55	.07
Netherlands	.48	.07
Norway	.38	.07
U.K.	.22	.05
U.S.A.	.30	.06

Empirical evidence on returns to scale is particularly scarce, and Denison's estimates are guesses. The evidence is usually confined to cross-section data for industry, and the magnitude of scale economies is not large.[52] Even at this level it is difficult to segregate the pure scale effect because of the large interfirm variations in vintages of capital. On the economy level, scale economies are even more difficult to isolate, particularly in time series. It is not possible to distinguish scale movements along a given production function from those which arise from neutral technical progress. Griliches and Ringstad have found economies of scale in Norwegian manufacturing of about .06 to .07.[53] This is only half the size of Denison's coefficient even though it applies to a sector of the economy where scale economies are most likely to occur.

Economies of scale figure importantly in several theories of economic growth, particularly the vicious and virtuous circle theories, where a high growth momentum contains a large self-generating element. Recently Kaldor has put great emphasis on economies of

52 See J. S. BAIN, *Industrial Organisation*, Wiley, New York, 1959 and *International Differences in Industrial Structure*, Yale, 1966.

53 See Z. GRILICHES and V. RINGSTAD, *Economies of Scale and the Form of the Production Function*, North Holland, Amsterdam, 1971.

scale, particularly in the industrial sector.[54] The empirical material which he uses to justify his emphasis on scale economies is a rather naive correlation between output and productivity. As the growth series are strongly inter-correlated, this approach may produce misleading results, particularly when the role of investment is virtually ignored as an instrument for growth.

Beckerman and Lamfalussy have also developed theories of export-led growth. They do not deny the importance of capital in the process but they give a heavy though unspecified weight to economies of scale.[55]

My own feeling is that Denison probably exaggerates economies of scale and I have cut his estimates by half.

Changes in Efficiency of Allocation of Labour

Denison has an important source of growth which he calls removal of "excessive allocation of labour to farming and self-employment". Shifts of labour from low productivity jobs in agriculture to other parts of the economy have been regarded as an important source of economic growth by several authors, who have treated this kind of labour movement as providing some sort of free bonus to the economy, quite different from the effect of job switching within industry. Kindleberger regarded it as an important source of growth in Europe in the 1950s. Its impact was stressed by a group of O.E.C.D. experts on agriculture, Kaldor considers the absence of this factor as a cause of the slow growth of the United Kingdom vis-à-vis the continental countries, and I emphasized its role in my study of growth in the 1950s.[56]

Denison's procedure is more complex than that of most other people who have analysed the problem, and it involves a double calculation: [57] (a) the contribution which labour released from agriculture makes to non-agricultural output (scaled down by 20-25 per cent to allow for the fact that total inputs probably increased less than labour); (b) the loss to farm output due to the withdrawal of farm labour. For the United States, the United Kingdom, and Denmark, he assumes that agricultural output fell by .33 per cent for every 1 per cent fall in employment, in North-West Europe the drop is assumed to be .25 per cent and in Italy zero. In addition, Denison makes an adjustment for movement of labour out of self-employment in non-agriculture, an adjustment which most other authors have not attempted. I think it was useful to quantify this, though the figures for self-employment outside agriculture are only rough estimates. The only modification I have made of Denison's procedure is to reduce the impact of this item by the difference between labour's share of G.N.P. and its share of national income.

54 See N. Kaldor, *Causes of the Slow Rate of Economic Growth of the United Kingdom*, Cambridge, 1966, with its heavy stress on Verdoorn's law.

55 See W. Beckerman and Associates, *The British Economy in 1975*, Cambridge, 1965, particularly Chapter II; A. Lamfalussy, *The United Kingdom and the Six: An Essay in Economic Growth in Western Europe*, Macmillan, London, 1963.

56 See C. P. Kindleberger, *Europe's Postwar Growth: The Role of Labour Supply*, Harvard, 1967; *Agriculture and Economic Growth*, O.E.C.D., Paris, 1967; N. Kaldor, *Causes of the Slow Rate of Economic Growth of the United Kingdom*, Cambridge, 1966; A. Maddison, *Economic Growth in the West*.

57 See Denison, *op. cit.*, pp. 211-15.

Advances of Knowledge

The last identified item in Denison's growth catalogue is advances in knowledge. This is often called disembodied technical progress by other writers. Denison assumes that it is a function of time and that its benefits are equal for all countries. The magnitude he picks is .76 percentage points a year — a figure he choses for the somewhat ethnocentric reason that it makes his residual for the U.S.A. zero. My own assumption is that technical progress is all embodied in either capital or labour and I make no allowance for this item.

Residual

Denison's residual is negative for Denmark, zero for the U.S.A. and positive for the other countries. His biggest residuals are for France, Germany and Italy, suggesting that non-identified sources of growth or errors of measurement are bigger in these countries than elsewhere. In my alternate account, the residuals are different, with negative figures for Belgium, Italy, the Netherlands, and Norway, and positive residuals elsewhere.

VI. Conclusions

The last lines of Tables 17 and 18 summarise the two sets of accounts. In my accounting (like that of Jorgenson and Griliches) factor input plays a much bigger role than for Denison. It explains threequarters of growth whereas for him it represents less than half. The important difference is that I give a much bigger weight to capital (bigger than Denison's figure for capital and disembodied progress combined). Labour plays roughly the same explanatory role in my analysis. Gains from trade are more important. They are a quarter of total factor productivity in my analysis and only 4 per cent in Denison's. My average residual is smaller than Denison's, and the range of my residuals between countries is also smaller.

Whether one opts for Denison's judgement, mine or something else, there is still a good deal of scope for improving on the accounts by further research within the framework of the Denisonian model.[58] Promising lines for further investigation would be research

TABLE 17

SUMMARY STATEMENT OF DENISON'S EXPLANATION OF 1950-1962 GROWTH

annual average percentage point contribution to growth rate

	Output	Capital	Labour	Reallocation of Labour	Gains from Trade	Economies of Scale	Disembodied Technical Progress	Residual
Belgium . . .	2.92	.41	.76	.35	.16	.40	.76	.08
Denmark . .	3.13	.99	.59	.58	.09	.42	.76	−.32
France . . .	4.21	.78	.45	.88	.07	.51	.76	.75
Germany . .	6.35	1.69	1.37	.90	.10	.70	.76	.80
Italy	5.35	.69	.96	1.26	.16	.62	.76	.89
Netherlands . .	4.29	1.03	.87	.47	.16	.55	.76	.44
Norway . . .	3.35	.93	.15	.77	.15	.45	.76	.14
U.K.	2.29	.51	.60	.10	.02	.27	.76	.03
U.S.A. . . .	3.36	.83	1.12	.29	.00	.36	.76	.00
Average . . .	3.92	.87	.76	.62	.10	.51	.76	.31

58 In a recent article Denison has made a comprehensive statement of the main items worth investigation. See E. F. DENISON, "Classification of Sources of Growth", *Review of Income and Wealth*, March 1972.

TABLE 18

SUMMARY STATEMENT OF ALTERNATE EXPLANATION OF 1950-1962 GROWTH

annual average percentage point contribution to growth rate

	Output	Non-residential fixed capital	Other capital	Labour	Reallocation of labour	Gains from trade	Non-trade scale effects	Residual
Belgium . . .	3.04	1.56	.09	.95	.30	.42	.10	−.38
Denmark . .	3.35	1.41	.34	.43	.51	.26	.13	.27
France . . .	4.12	1.77	.29	.86	.75	.17	.23	.05
Germany . .	6.38	3.14	.41	1.07	.77	.28	.27	.44
Italy	5.40	1.95	.18	1.70	1.09	.39	.24	−.15
Netherlands . .	4.09	2.22	.41	.81	.40	.50	.10	−.35
Norway . . .	3.61	2.25	.12	.11	.64	.48	.12	−.11
U.K.	2.64	1.15	.12	.66	.09	.06	.12	.44
U.S.A. . . .	3.45	1.35	.46	.84	.25	.01	.17	.37
Average . . .	4.01	1.87	.27	.83	.53	.29	.16	.06

Source: Column 1 derived from Table 1; column 2 from the last column of Table 9 with .50 added to Germany and .50 subtracted from Norway for changes in capacity use; column 3 represents the impact of dwellings, international assets and inventories (we used Denison's figures modified to show the impact on G.N.P. rather than national income); labour from last column of Table 12; reallocation of labour is Denison's figure scaled down by difference between labour's share in G.N.P. and in national income; gains from trade is a doubling of Denison's figure (my Table 13) and incorporates the impact of scale economies arising from trade (my Table 15); non-trade scale effects is half of Denison's economies of scale (see my Table 16) minus economies of scale from trade (my Table 15).

into scrapping rates and changes in the lives of assets as a guide to rates of technical progress. It would be helpful to have further information on the size and impact of on-the-job training and on wage profiles by level of education and training; on the dynamic effects of European integration, and on economies of scale. Hypotheses could be tested more rigorously by extending the comparisons backwards and strengthening the historical data. In the case of the U.S.A., Denison, Kendrick, Jorgenson and Griliches have applied this type of analysis to data for a much longer period, but little has so far been done on the European data. I think Denison's judgement on Europe might have been different if he had had a longer time perspective, for he might have given more weight to the postwar

acceleration in growth rates and capital formation, which have no counterpart in the U.S. experience he analysed earlier. Hypotheses can be further tested by extending the analysis to the 1960s and to a few more countries like Japan on which data are now available.

Some writers would attribute greater weight to changes or inter-country variations in product-mix than Denison does. His big adjustment which concerns the breakdown of output refers to the movement from agricultural to non-agricultural sector. He does not feel that movements within the rest of the economy have too much effect on growth and therefore sees no point in the kind of detailed sector analysis carried out by Kendrick. For the big countries I tend to agree with him, but in a small country like Norway the structural differentials may be important. The differing importance of the service sector in the U.S. and Europe may also be significant.

In all the countries with which Denison deals, governments spend a good deal on various services which have an impact on growth. We have taken the impact of government capital into account and allowed for the effect of education. Some government spending, e.g. on research and development, makes its impact via the rate of technical progress, and cannot be separately specified as a cause of growth (without double counting) unless one is trying to decompose the factors making for technical progress. However, there are other non-specified government services which are intended to stimulate growth, e.g. Sweden's labour market policy, or the technical advice provided to farmers in most countries. These should figure in the accounting. One possible procedure would be to treat them as intermediate rather than final goods and deduct them from output.

Finally, I would stress again that Denison's approach is concerned with proximate rather than ultimate causality. Economic policy-makers want a model which shows how they can influence growth. We therefore need to go further than Denison in showing how the variables discussed can be affected by policy. The amendments I have made to Denison are intended to provide an explanation of growth which is more useful and meaningful from this standpoint, but the analysis needs to be developed much further.[59] In particular, we need

[59] In a study of 22 developing countries, I tried to distinguish crudely between autonomous and policy-induced growth within the framework of a Denisonian model. See A. Maddison, *Economic Progress and Policy in Developing Countries*, Allen and Unwin, London, 1970.

to explain what determines the rate of technical progress, what motivates high rates of investment, and we need to know more about the important interactions between the causes of growth.

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APPENDIX A

GROWTH OF G.N.P. AND NON-RESIDENTIAL FIXED CAPITAL FORMATION 1920-62

The data in this appendix were used to estimate the 1950 capital stock shown in Table 5. This was done by cumulating the increment in capital stock from mid-1920 to mid-1950 shown in column 3 of these tables, i.e. the figures for 1921-49 and half the values for 1920 and 1950. The first column of Table 6 is the average capital output ratio for countries where we could calculate the 1950 capital stock. The first column of Table 8 is the average of the quality-adjusted capital stock (derived from the fifth column of the Appendix tables) for the seven countries where figures were available. For 1920-50 the sources used were as follows:

Denmark: G.N.P. and investment from K. Bjerke and N. Ussing, *Studier over Danmarks National Product 1870-1950*, Gads, Copenhagen 1958, pp. 147 and 151. Housing investment was assumed to be 20 per cent of total fixed investment.

France: G.D.P. and investment for 1920-39 and 1946-50 from J. J. Carré, P. Dubois and E. Malinvaud, *La Croissance Française*, Seuil, Paris, 1972, pp. 35 and 652, investment figures reduced by 25 per cent to eliminate housing and repairs component of construction, 1940 to 1944 figures for investment are my guesses. 1940-44 G.D.P. derived from Sauvy in *Journal Officiel*, 7 April 1954. It was assumed that war damage destroyed capital equivalent to 4 per cent of the 1950 stock.

Germany: G.N.P. 1920-24 roughly estimated assuming half of G.N.P. to move with industrial production (see *Industrial Statistics 1900-1955*, O.E.E.C., 1955, p. 4) and the rest to have been stable; 1925-38 from *Statistisches Jahrbuch für die Bundesrepublik Deutschland 1961*, p. 544, 1939-44 derived from a graph in J. K. Galbraith and Associates, *The Effects of Strategic Bombing on the*

German War Economy, U.S. Strategic Bombing Survey, October 31, 1945;[60] it was assumed that in 1945 G.N.P. fell to half of 1944 levels, 1946 and 1947 figures are my guesses; 1948-49 from O.E.E.C., *Europe and the World Economy*, Eleventh Annual Economic Review, Paris, 1960, p. 116. Investment figures for 1920-24 are my guesses, 1925-37 are from the sources mentioned in A. MADDISON, *Economic Growth in the West*, p. 236; 1938-44 from *Die deutsche Industrie im Kriege 1939-45*, D.I.W., Duncker und Humblot, Berlin, 1954, p. 160; 1945-48 was estimated on the assumption that total fixed non-residential investment moved parallel to Krengel's estimates for industry, see R. KRENGEL, *Anlagevermögen, Produktion und Beschäftigung der Industrie im Gebiet der Bundesrepublik von 1924 bis 1956*, D.I.W., Berlin, 1958, p. 98. Krengel estimated that war damage destroyed the equivalent of 27 per cent of the 1936 capital stock of German industry, and postwar dismantling amounted to almost another 7 per cent of this (see R. KRENGEL, *op. cit.*, pp. 76 and 104). Kitner has presented estimates for other sectors which suggest that for the whole economy, losses of fixed non-residential capital from the two sources amounted to about a sixth of the prewar stock, see W. KIRNER, *Zeitreihen für das Anlagevermögen der Wirtschaftsbereiche in der Bundesrepublik Deutschland*, D.I.W., Berlin, 1968, pp. 82-3. This implies that the 1950 stock should be reduced about 10 per cent to allow for war damage and dismantling.

Italy: Output at 1938 market prices from O. VITALI, "Il valore aggiunto dell'Italia a prezzi costanti, in totale e per rami di attività economica, dal 1861 al 1964", *Rivista Italiana di Demografia e Statistica*, June-December 1967. Investment rates from *Indagine Statistica sullo Sviluppo del Reddito Nazionale dell'Italia dal 1861 al 1956, Annali di Statistica*, Serie VIII, vol. 9, Istituto Centrale di Statistica, Roma, 1957. Investment was expressed as a ratio to G.N.P. increased to include certain government purchases of goods and services which are treated in the Italian study as intermediate products, in order to conform with the O.E.C.D. standardised system. According to figures given by G. FUÀ, *Notes on Italian Economic Growth 1861-1964*, Giuffrè, Milano, 1965, pp. 51 and 87, it would appear that losses due to war damage would lead to a reduction of 9.3 per cent in the 1950 stock of equipment, and a smaller fraction for buildings, say 6 per cent for all non-residential capital.

Norway: Figures for output refer to gross domestic product at market prices and for 1920-39 are from *National Accounts, 1900-1929*, Central Bureau of Statistics, Oslo, 1953. 1940-45 from O. AUKRUST and P. J. BJERVE, *Hva krigen kostet Norge*, Oslo, 1945. The original figures of gross fixed investment were

[60] Different figures for wartime social product are given in *Die deutsche Wirtschaft zwei Jahre nach dem Zusammenbruch*, D.I.W., Nauck, Berlin, 1947, p. 269, i.e., 99.2, 91.6, 91.1, 90.1, 90.1 and 81.9 for 1939-44.

adjusted downwards by a third to eliminate repair and maintenance expenditures. Investment figures from 1940-45 are my estimates. Movement in output 1939 to 1946-50 from O.E.E.C. sources and refers to G.N.P. 1946-49 capital formation estimated from data including housing in *The Norwegian Postwar Economy*, Central Bureau of Statistics, Oslo, 1965, p. 118. Figures for wartime capital formation and G.N.P. are my guesses. I have assumed that war losses were equal to 3 per cent of the 1950 capital stock in calculating the capital output ratios of Table 5.

United Kingdom: Output figures refer to G.D.P. at factor cost (expenditure figures) from *The British Economy: Key Statistics 1900-70*, London and Cambridge Economic Service, London. 1939-45 from estimates supplied by Professor R. C. O. Matthews. Investment 1920-38 from C. H. FEINSTEIN, *Domestic Capital Formation in the United Kingdom 1920-1938*, Cambridge, 1965, related to G.N.P. at market prices. For wartime years, I used *National Income and Expenditure of the United Kingdom 1938-1946*, Cmd. 7099, London, 1947; I have made allowance for £1 billion of government investment which was treated in the national accounts as consumption, see T. BARNA, "Investment in Industry - Has Britain Lagged?", *The Banker*, April 1957. I have assumed that war damage amounted to 3 per cent of the 1950 stock in calculating the figure for Table 5.

United States: Output figure (G.N.P., Commerce concept) from J. W. KENDRICK, *Productivity Trends in the United States*, Princeton, 1961, pp. 299-301. Investment from S. KUZNETS, *Capital in the American Economy*, Princeton, 1961, pp. 490 and 494 (gross fixed investment, minus military construction and munitions).

* * *

All Countries: The figures on G.N.P. and capital formation from 1950 onwards are taken from O.E.C.D. national accounts publications. The U.S. figures for investment were increased to allow for government equipment investment which is excluded from O.E.C.D. figures, and Norwegian figures were adjusted to exclude an element of repair and maintenance which O.E.C.D. does not delete. See *Economic Growth in the West*, Appendix I for the procedure used.

BELGIUM

	G.N.P. (1950=100)	Ratio of gross fixed non-residential capital formation to G.N.P. at current prices	Gross increment to capital stock (as percentage of 1950 G.N.P.)	Average quality of each year's increment to capital stock (vintage effect) 1950 quality =100	Quality adjusted gross increment to capital stock (as percent of 1950 G.N.P.)
1950	100.0	11.5	11.5	100.00	11.50
1951	105.7	10.4	11.0	102.00	11.22
1952	104.8	10.8	11.3	104.04	11.76
1953	109.0	12.0	13.1	106.12	13.90
1954	113.1	12.1	13.7	108.24	14.83
1955	118.5	12.8	15.2	110.41	16.78
1956	121.8	13.8	16.8	112.62	18.92
1957	124.7	12.9	16.1	114.87	18.49
1958	123.8	12.4	15.4	117.17	18.04
1959	126.6	13.0	16.5	119.51	19.72
1960	133.6	13.7	18.3	121.90	22.31
1961	140.1	14.6	20.5	124.34	25.49
1962	147.9	15.9	23.5	126.82	29.80

DENMARK

	G.N.P. (1950=100)	Ratio of gross fixed non-residential capital formation to G.N.P. at current prices	Gross increment to capital stock (as percentage of 1950 G.N.P.)	Average quality of each year's increment to capital stock (vintage effect) 1950 quality =100	Quality adjusted gross increment to capital stock (as percent of 1950 G.N.P.)
1920	(45.5)	(8.1)	3.69	54.55	2.01
1921	46.5	8.1	3.77	55.66	2.10
1922	49.7	8.3	4.13	56.80	2.35
1923	56.3	8.4	4.73	57.96	2.74
1924	57.6	8.6	4.95	59.14	2.93
1025	56.1	8.1	4.54	60.35	2.74
1926	57.8	7.7	4.45	61.58	2.74
1927	59.9	7.5	4.49	62.84	2.82
1928	62.3	7.7	4.80	64.12	3.08
1929	64.3	8.6	5.53	65.43	3.62
1930	67.2	10.9	7.32	66.76	4.89
1931	68.2	10.9	7.43	68.12	5.06
1932	66.8	8.2	5.48	69.51	3.81
1933	67.8	9.2	6.24	70.93	4.43
1934	70.4	10.1	7.11	72.38	5.15
1935	72.2	9.8	7.08	73.86	5.23
1936	74.2	9.5	7.05	75.36	5.31
1937	76.8	9.6	7.37	76.90	5.67
1938	77.0	9.8	7.55	78.47	5.92
1939	81.7	10.3	8.42	80.07	6.74
1940	69.6	7.6	5.29	81.71	4.32
1941	63.1	7.7	4.86	83.38	4.05
1942	64.3	8.3	5.34	85.08	4.54
1943	71.0	7.7	5.47	86.81	4.75
1944	77.8	5.4	4.20	88.58	3.72
1945	72.0	5.5	3.96	90.39	3.58
1946	81.6	9.1	7.43	92.24	6.85
1947	85.4	10.7	9.14	94.12	8.60
1948	88.1	11.7	10.31	96.04	9.90
1949	93.3	13.1	12.22	98.00	11.98
1950	100.0	12.7	12.70	100.00	12.70
1950	100.0	12.7	12.7	100.00	12.70
1951	99.8	13.2	13.2	102.00	13.46
1952	101.1	14.0	14.2	104.04	14.77
1953	107.1	13.8	14.8	106.12	15.71
1954	110.6	13.9	15.4	108.24	16.67
1955	110.6	13.1	14.5	110.41	16.01
1956	113.1	13.6	15.4	112.62	17.34
1957	118.8	13.8	16.4	114.87	18.84
1958	122.0	14.6	17.8	117.17	20.86
1959	130.5	15.6	20.4	119.51	24.38
1960	138.6	16.2	22.5	121.90	27.43
1961	146.9	16.9	24.8	124.34	30.84
1962	155.2	17.1	26.5	126.82	33.60

FRANCE

	G.N.P. (1950=100)	Ratio of gross fixed non-residential capital formation to G.N.P. at current prices	Gross increment to capital stock (as percentage of 1950 G.N.P.)	Average quality of each year's increment to capital stock (vintage effect) 1950 quality =100	Quality adjusted gross increment to capital stock (as percent of 1950 G.N.P.)
1920	56.5	(10.0)	5.65	54.55	3.08
1921	55.7	(10.0)	5.57	55.66	3.10
1922	64.3	10.4	6.69	56.80	3.80
1923	67.8	10.5	7.12	57.96	4.13
1924	74.8	12.5	9.35	59.14	5.53
1925	75.7	11.4	8.63	60.35	5.21
1926	76.5	13.1	10.02	61.58	6.17
1927	75.7	11.0	8.33	62.84	5.23
1928	80.0	13.1	10.48	64.12	6.72
1929	87.0	13.7	11.92	65.43	7.80
1930	84.3	15.6	13.15	66.76	8.78
1931	80.9	14.3	11.57	68.12	7.88
1932	77.4	12.3	9.52	69.51	6.62
1933	80.9	11.8	9.55	70.93	6.77
1934	80.9	11.0	8.90	72.38	6.44
1935	78.3	11.0	8.61	73.86	6.36
1936	79.1	11.5	9.10	75.36	6.86
1937	83.5	11.7	9.77	76.90	7.51
1938	83.5	10.1	8.43	78.47	6.62
1939	87.0	(12.0)	10.44	80.07	8.36
1940	71.8	(5.0)	3.59	81.71	2.93
1941	56.9	(5.0)	2.85	83.38	2.38
1942	50.9	(5.0)	2.55	85.08	2.17
1943	48.3	(5.0)	2.42	86.81	2.10
1944	42.2	(5.0)	2.11	88.58	1.87
1945	45.8	(5.0)	2.29	90.39	2.07
1946	69.6	(10.0)	6.96	92.24	6.42
1947	75.7	(12.5)	9.46	94.12	8.90
1948	87.0	(15.0)	13.05	96.04	12.53
1949	93.0	14.5	13.49	98.00	13.22
1950	100.0	13.6	13.60	100.00	13.60
1950	100.0	13.6	13.6	100.00	13.60
1951	106.1	13.9	14.7	102.00	14.99
1952	108.7	13.2	14.3	104.04	14.88
1953	112.0	12.5	14.0	106.12	14.86
1954	117.4	12.3	14.4	108.24	15.59
1955	124.2	13.1	16.3	110.41	18.00
1956	130.5	13.6	17.7	112.62	19.93
1957	138.3	14.4	19.9	114.87	22.86
1958	141.9	14.0	19.9	117.17	23.32
1959	146.1	14.9	21.8	119.51	26.05
1960	156.5	15.1	23.6	121.90	28.77
1961	164.9	16.4	27.0	124.34	33.57
1962	176.2	16.8	29.6	126.82	37.54

GERMANY

	G.N.P. (1950=100)	Ratio of gross fixed non-residential capital formation to G.N.P. at current prices	Gross increment to capital stock (as percentage of 1950 G.N.P.)	Average quality of each year's increment to capital stock (vintage effect) 1950 quality =100	Quality adjusted gross increment to capital stock (as percent of 1950 G.N.P.)
1920	(47.4)	(5.0)	2.37	54.55	1.30
1921	(51.7)	(5.0)	2.59	55.66	1.44
1922	(53.6)	(5.0)	2.68	56.80	1.52
1923	(45.5)	(5.0)	2.28	57.96	1.32
1924	(53.1)	(10.0)	5.31	59.14	3.14
1025	57.4	11.4	6.54	60.35	3.95
1926	59.1	11.1	6.56	61.58	4.04
1927	64.9	11.6	7.53	62.84	4.73
1928	67.8	11.5	7.80	64.12	5.00
1929	67.5	9.7	6.55	65.43	4.29
1930	66.7	9.0	6.00	66.76	4.01
1931	61.5	7.2	4.43	68.12	3.02
1932	56.9	6.2	3.53	69.51	2.45
1933	60.3	7.2	4.34	70.93	3.08
1934	65.7	10.3	6.77	72.38	4.90
1935	71.7	13.0	9.32	73.86	6.88
1936	77.9	14.0	10.91	75.36	822
1937	86.7	14.7	12.74	76.90	9.80
1938	95.3	17.0	16.20	78.47	12.71
1939	105.5	15.8	16.67	80.07	13.35
1940	100.0	12.3	12.30	81.71	10.05
1941	101.5	11.0	11.17	83.38	9.31
1942	100.0	9.1	9.10	85.08	7.74
1943	100.0	7.8	7.80	86.81	6.77
1944	109.3	5.9	6.45	88.58	5.71
1945	(54.7)	2.6	1.42	90.39	1.28
1946	(57.2)	2.7	1.54	92.24	1.42
1947	(63.6)	3.2	2.04	94.12	1.92
1948	70.5	6.4	4.51	96.04	4.33
1949	81.9	13.3	10.89	98.00	10.67
1950	100.0	14.1	14.10	100.00	14.10
1950	100.0	14.1	14.1	100.00	14.10
1951	110.9	14.2	15.7	102.00	16.01
1952	120.9	14.1	17.0	104.04	17.75
1953	130.5	14.8	19.3	106.12	20.48
1954	139.7	15.5	21.7	108.24	23.49
1955	156.3	17.3	27.0	110.41	29.81
1956	167.1	17.5	29.2	112.62	32.89
1957	176.5	16.7	29.5	114.87	33.89
1958	182.1	17.0	31.0	117.17	36.32
1959	194.9	17.8	34.7	119.51	41.47
1960	212.1	18.5	39.2	121.90	47.78
1961	223.5	19.3	43.1	124.34	53.59
1962	232.9	19.8	46.1	126.82	58.46

ITALY

	G.N.P. (1950=100)	Ratio of gross fixed non-residential capital formation to G.N.P. at current prices	Gross increment to capital stock (as percentage of 1950 G.N.P.)	Average quality of each year's increment to capital stock (vintage effect) 1950 quality =100	Quality adjusted gross increment to capital stock (as percent of 1950 G.N.P.)
1920	51.3	12.1	6.21	54.55	3.39
1921	49.1	10.5	5.16	55.66	2.87
1922	54.8	11.9	6.52	56.80	3.70
1923	61.2	12.8	7.83	57.96	4.54
1924	63.0	15.7	9.89	59.14	5.85
1025	66.3	16.2	10.74	60.35	6.48
1926	67.4	16.8	11.32	61.58	6.97
1927	67.0	15.5	10.39	62.84	6.53
1928	71.4	14.7	10.50	64.12	6.73
1929	73.7	14.3	10.54	65.43	6.90
1930	70.8	14.2	10.05	66.76	6.71
1931	70.3	12.5	8.79	68.12	5.99
1932	71.7	10.7	7.67	69.51	5.33
1933	70.9	12.0	8.51	70.93	6.04
1934	70.9	12.6	8.93	72.38	6.46
1935	75.4	13.2	9.95	73.86	7.35
1936	73.6	14.9	10.97	75.36	8.27
1937	79.4	14.5	11.51	76.90	8.85
1938	80.5	14.0	11.27	78.47	8.84
1939	86.2	14.7	12.67	80.07	10.14
1940	85.0	15.4	13.09	81.71	10.70
1941	84.3	13.7	11.55	83.38	9.63
1942	80.4	10.2	8.20	85.08	6.98
1943	66.4	8.2	5.44	86.81	4.72
1944	51.7	5.2	2.69	88.58	2.38
1945	44.7	7.4	3.31	90.39	2.99
1946	61.1	15.7	9.59	92.24	8.85
1947	74.7	17.5	13.07	94.12	12.30
1948	82.4	17.0	14.01	96.04	13.46
1949	92.5	15.5	14.34	98.00	14.05
1950	100.0	14.8	14.80	100.00	14.80
1950	100.0	14.8	14.8	100.00	14.80
1951	107.5	13.9	14.9	102.00	15.20
1952	112.2	14.8	16.6	104.04	17.27
1953	120.7	14.8	17.9	106.12	19.00
1954	125.4	14.9	18.7	108.24	20.24
1955	133.6	14.8	19.8	110.41	21.86
1956	139.6	14.7	20.5	112.62	23.09
1957	147.1	15.2	22.4	114.87	25.73
1958	154.3	14.4	24.2	117.17	26.01
1959	164.4	14.7	22.2	119.51	28.92
1960	174.8	16.2	28.3	121.90	34.50
1961	188.4	16.8	31.7	124.34	39.42
1962	200.1	16.6	33.2	126.82	42.10

NETHERLANDS

	G.N.P. (1950=100)	Ratio of gross fixed non-residential capital formation to G.N.P. at current prices	Gross increment to capital stock (as percentage of 1950 G.N.P.)	Average quality of each year's increment to capital stock (vintage effect) 1950 quality =100	Quality adjusted gross increment to capital stock (as percent of 1950 G.N.P.)
1950	100.0	16.4	16.4	100.00	16.40
1951	103.0	15.9	16.4	102.00	16.73
1952	105.1	15.0	15.8	104.04	16.44
1953	114.3	16.8	19.2	106.12	20.38
1954	122.1	17.3	21.1	108.24	22.84
1955	131.2	19.1	25.1	110.41	27.71
1956	135.7	20.5	27.8	112.62	31.31
1957	140.0	20.5	28.7	114.87	32.97
1958	139.5	17.8	24.8	117.17	29.06
1959	146.4	18.8	27.5	119.51	32.87
1960	158.7	19.5	30.9	121.90	37.67
1961	164.0	20.3	33.3	124.34	41.41
1962	170.2	20.2	34.4	126.82	43.62

NORWAY

	G.N.P. (1950=100)	Ratio of gross fixed non-residential capital formation to G.N.P. at current prices	Gross increment to capital stock (as percentage of 1950 G.N.P.)	Average quality of each year's increment to capital stock (vintage effect) 1950 quality =100	Quality adjusted gross increment to capital stock (as percent of 1950 G.N.P.)
1920	46.0	17.9	8.23	54.55	4.49
1921	41.4	15.4	6.38	55.66	3.55
1922	46.3	11.4	5.28	56.80	3.00
1923	47.7	11.6	5.53	57.96	3.21
1924	47.6	11.3	5.38	59.14	3.18
1925	49.6	11.4	5.65	60.35	3.41
1926	50.1	10.9	5.46	61.58	3.36
1927	52.4	9.9	5.19	62.84	3.26
1928	51.5	11.6	5.97	64.12	3.83
1929	58.7	12.2	7.16	65.43	4.68
1930	63.2	12.9	8.15	66.76	5.44
1931	58.3	12.3	7.17	68.12	4.88
1932	62.1	10.0	6.21	69.51	4.32
1933	63.6	10.2	6.49	70.93	4.60
1934	64.9	11.0	7.14	72.38	5.17
1935	68.4	12.2	8.34	73.86	6.16
1936	72.1	13.3	9.59	75.36	7.23
1937	74.6	15.2	11.34	76.90	8.72
1938	76.3	15.1	11.52	78.47	9.04
1939	80.1	15.2	12.18	80.07	9.75
1940	73.0	(9.0)	6.57	81.71	5.37
1941	74.8	(6.0)	4.49	83.38	3.75
1942	71.9	(6.0)	4.32	85.08	3.68
1943	70.5	(6.0)	4.23	86.81	3.67
1944	66.8	(6.0)	4.01	88.58	3.55
1945	74.5	(10.0)	7.45	90.39	6.74
1946	79.0	19.5	15.41	92.24	14.21
1947	89.8	21.4	19.22	94.12	18.09
1948	93.4	21.5	20.08	96.04	19.28
1949	95.0	21.4	20.33	98.00	19.92
1950	100.0	20.7	20.70	100.00	20.70
1950	100.0	20.7	20.70	100.00	20.70
1951	103.0	18.2	18.75	102.00	19.13
1952	107.0	19.4	20.76	104.04	21.60
1953	111.1	20.7	23.00	106.12	24.41
1954	116.4	22.3	25.96	108.24	28.10
1955	118.8	22.8	27.09	110.41	29.91
1956	124.8	21.5	26.83	112.62	30.22
1957	128.2	21.9	28.08	114.87	32.26
1958	129.7	25.5	33.07	117.17	38.75
1959	134.1	23.6	31.65	119.51	37.82
1960	138.9	22.0	30.56	121.90	37.25
1961	147.8	23.0	33.99	124.34	42.26
1962	154.8	22.5	34.84	126.82	44.18

UNITED KINGDOM

	G.N.P. (1950=100)	Ratio of gross fixed non-residential capital formation to G.N.P. at current prices	Gross increment to capital stock (as percentage of 1950 G.N.P.)	Average quality of each year's increment to capital stock (vintage effect) 1950 quality =100	Quality adjusted gross increment to capital stock (as percent of 1950 G.N.P.)
1920	63.9	(6.7)	4.28	54.55	2.33
1921	56.2	6.4	3.60	55.66	2.00
1922	56.9	6.3	3.58	56.80	2.03
1923	58.3	5.8	3.38	57.96	1.96
1924	60.0	6.0	3.60	59.14	2.13
1025	63.7	6.0	3.82	60.35	2.31
1926	59.9	5.4	3.23	61.58	1.99
1927	65.4	5.4	3.53	62.84	2.22
1928	67.3	6.0	4.04	64.12	3.59
1929	68.5	6.0	4.11	65.43	2.69
1930	68.0	6.2	4.22	66.76	2.82
1931	63.5	6.2	3.94	68.12	2.68
1932	63.6	5.1	3.24	69.51	2.25
1933	64.0	4.6	2.94	70.93	2.09
1934	69.7	5.4	3.76	72.38	2.72
1935	72.5	5.8	4.21	73.86	3.11
1936	74.6	6.6	4.92	75.36	3.71
1937	78.6	7.3	5.74	76.90	4.41
1938	81.6	7.2	5.88	78.47	4.61
1939	87.9	(7.5)	6.59	80.07	5.28
1940	94.7	(6.0)	5.68	81.71	4.64
1941	99.7	(4.0)	3.99	83.38	3.33
1942	102.6	(4.0)	4.10	85.08	3.49
1943	105.4	(4.0)	4.22	86.81	3.66
1944	103.9	(2.0)	2.08	88.58	1.84
1945	100.4	(5.0)	5.02	90.39	4.54
1946	96.0	(9.0)	8.64	92.24	7.97
1947	92.0	(9.0)	8.28	94.12	7.79
1948	93.9	(9.0)	8.45	96.04	8.12
1949	96.9	9.8	9.50	98.00	9.31
1950	100.0	10.3	10.20	100.00	10.20
1950	100.0	10.2	10.2	100.00	10.20
1951	102.3	10.2	10.4	102.00	10.61
1952	101.8	10.1	10.3	104.04	10.72
1953	106.6	10.1	10.8	106.12	11.46
1954	110.7	10.6	11.7	108.24	12.66
1955	114.1	11.3	12.9	110.41	14.24
1956	116.5	11.8	13.7	112.62	15.43
1957	118.8	12.6	15.0	114.87	17.23
1958	119.9	12.8	15.3	117.17	17.93
1959	124.4	12.8	15.9	119.51	19.00
1960	130.3	13.2	17.2	121.90	20.97
1961	134.8	13.9	18.7	124.34	23.25
1962	136.6	13.5	18.4	126.82	23.34

UNITED STATES

	G.N.P. (1950=100)	Ratio of gross fixed non-residential capital formation to G.N.P. at current prices	Gross increment to capital stock (as percentage of 1950 G.N.P.)	Average quality of each year's increment to capital stock (vintage effect) 1950 quality =100	Quality adjusted gross increment to capital stock (as percent of 1950 G.N.P.)
1920	39.1	11.7	4.57	54.55	2.49
1921	38.2	10.7	4.09	55.66	2.28
1922	40.4	11.7	4.73	56.80	2.69
1923	45.8	12.8	5.86	57.96	3.40
1924	47.1	12.5	5.89	59.14	3.48
1025	48.3	13.3	6.42	60.35	3.87
1926	51.4	13.5	6.94	61.58	4.27
1927	51.9	13.5	7.01	62.84	4.41
1928	52.6	13.6	7.15	64.12	4.58
1929	55.7	14.2	7.91	65.43	5.18
1930	50.8	13.6	6.91	66.76	4.61
1931	47.7	11.0	5.25	68.12	3.58
1932	40.8	8.2	3.35	69.51	2.33
1933	39.6	8.0	3.17	70.93	2.25
1934	43.1	9.6	4.14	72.38	3.00
1935	48.8	9.9	4.83	73.86	3.57
1936	53.8	12.6	6.78	75.36	5.11
1937	58.2	12.8	7.45	76.90	5.73
1938	55.1	11.7	6.45	78.47	5.06
1939	59.2	11.9	7.04	80.07	5.64
1940	64.6	11.8	7.62	81.71	6.23
1941	74.0	12.0	8.88	83.38	7.40
1942	82.5	8.5	7.01	85.08	5.96
1943	90.8	5.2	4.72	86.81	4.10
1944	98.0	4.7	4.61	88.58	4.08
1945	96.5	5.7	5.50	90.39	4.97
1946	88.4	8.0	7.07	92.24	6.52
1947	87.6	10.3	9.02	94.12	8.49
1948	92.3	11.1	10.25	96.04	9.84
1949	91.0	11.1	10.10	98.00	9.90
1950	100.0	13.7	13.70	100.00	13.70
1950	100.0	13.7	13.7	100.00	13.70
1951	108.1	13.6	14.7	102.00	15.00
1952	111.4	13.1	14.6	104.04	15.19
1953	116.3	13.3	15.5	106.12	16.45
1954	114.7	13.5	15.5	108.24	1678
1955	123.5	13.3	16.4	110.41	18.11
1956	125.7	14.3	18.0	112.62	20.27
1957	127.6	14.3	18.2	114.87	20.91
1958	126.6	12.9	16.3	117.17	19.10
1959	134.3	12.6	16.9	119.51	24.14
1960	137.5	12.9	17.7	121.90	21.58
1961	140.5	(12.4)	17.4	124.34	21.64
1962	149.5	(12.6)	18.8	126.82	23.84

A. M.