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Factors of Economic Development: A Review of Recent Research¹⁾

by

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1. On Economic Miracles

The growth experiences of the Western countries during the post-war period are, in many respects, quite perplexing - so perplexing, in fact, that references have been made to miracles to describe them. We have been told, in turn, about "the Belgian miracle", "the German and the Italian miracle" and - more recently - about "the French miracle".

One observation is in order: When a phenomenon is being characterized as "a miracle", the normal meaning of this is that the phenomenon goes against our conception of reality. If so, we may safely assume that it is our theoretical insight which is not up to the standard. In this particular case we must suspect that it is our models of economic growth which are in need of improvement.

Should this be the case, it is not a state of affairs which should easily be dismissed: If it is true that our understanding of the growth process is insufficient to account for the experiences of the past, then the implication is that we do not know for sure which actions will promote the maximum rate of growth in the future.

1) This paper was originally read to a seminar for the senior staff of national productivity centers, held in Bruxelles on June 4.-7. 1963 by l'Office Belge pour l'Accroissement de la Productivité. It is reproduced here in the form in which it was first presented, except that necessary references to literature have been added. I acknowledge the help of Mr. Henry Peskin, of Princeton University, who during a stay in Norway undertook to put my draft into proper English style.

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Much has been written on economic growth in recent years, and much research has been done by international organizations and individual scholars. In this talk I propose to attempt the impossible: It is my intention to try to give a birds eye view of this vast literature and to answer, as an economist, the following question: What do we know today about the forces which may cause one economy to grow more quickly than another?

Let me advance one of my conclusions: One reason why we have so often found the facts hard to explain is that we have seriously overestimated the rôle of capital as a factor of economic development. The truth could be that the mere accumulation of capital is less instrumental to growth than we used to believe, and that the "human factor" - technical progress, organization, and the advance of know-how - matters much more than we realized.

2. The International League Table of Growth

As a back-ground to what follows, the facts about the growth experiences of some 20 countries during the 1950's have been brought together in table 1. The content of this "league table" is so well known by now that comments are hardly needed.

The most striking feature of the table, no doubt, is the very great spread of the observed growth rates; as given in columns (1) they range from 7.5 per cent in Western Germany to a mere 1.4 per cent in Ireland. What a tremendous difference this is can be illustrated by pointing out one implication: If such rates were permanently maintained for five decades, the lower rate would lead to an exact doubling of the national product whereas the higher rate would result in the national product being increased 37 fold.

However, the most important thing to be noted is that growth rates such as those which the world has experienced during the 1950's are, by all historical standards, extremely high. To make this clearer, let me mention that there are by now about twenty countries in the world for which national income or product series exist for 50 years or more. In none of these countries has the long-term per capita growth rate exceeded 2.5 per cent a year. Rates of rather less than 1.5 per cent a year have been much more typical²⁾. The puzzling thing about the post-war period, therefore, is not why some countries have had comparably low rates of growth. The puzzle is

2) Simon Kuznets: Six Lectures on Economic Growth, Illinois & London, 1959, pp. 20-21.

rather why others have been able to grow at such extremely high rates as 4 per cent, 5 per cent, or more.

Such, then, are the facts. How do we account for them?

3. Research of the International Organizations: The Findings

Two of the great international organizations - OECD and the United Nation's Economic Commission for Europe - have lately engaged themselves in studies of the growth experiences of their member countries. Both have recently published their reports³⁾. It may serve a useful purpose if I use the first part of my time to summarize the main conclusions which emerge from these reports.

One could say, I suppose, that the OECD and ECE-studies have produced more negative conclusions than positive ones. But even negative conclusions - demonstrations that given hypotheses are refuted by the facts - no doubt are of value.

First, thanks to the OECD's work on data, we now have to accept as an established fact that the observed differences of the growth rates of the European countries are true differences. They cannot be explained away as the effects of statistical conventions - such as the choice of period of comparisons, differences in definitions, or differences in price weights⁴⁾.

A second hypothesis which appears to have been refuted, is that observed differences in growth rates can be accounted for only in part by differences in industrial structure. It is true, of course, that countries fortunately endowed with many quickly expanding industries (chemicals, machinery) have had advantages as compared with countries more heavily engaged in stagnating industries (such as coal and textiles). The studies bring out, however, that these differences in industrial structure vary so little from one European country to another that they cannot explain much (though Luxembourg, with her heavy reliance on steel, may be an exception)⁵⁾.

3) The discussion in the text is based on OECD: Policies for Economic Growth, a report to the Economic Policy Committee by Working Party No 2 on Policies for the promotion of economic growth, Paris 1962, and unpublished working documents from the OECD secretariat (hence forward referred to as the "OECD study") and United Nations: Economic Survey of Europe 1961, Part II, by the Economic Commission of Europe (referred to as the "ECE study"). The latter, so far, has been made available only in advance copies and in part as manuscript; it is much too valuable, however, for not being drawn upon for my purpose.

4) The significance of the choice of periods of comparisons and of definitions was investigated by OECD, the problem of prices by ECE (ECE study, Ch. II, pp. 22-23).

5) ECE study, Ch. III, especially Section 3.

Thirdly, it has been clearly demonstrated that differences in growth rates between countries cannot be explained in terms of some countries having devoted more resources to capital formation than others, (see diagram A)⁶⁾. True, it appears from this diagram that there is some tendency for the rate of growth of output to have been highest in those countries which have invested most. But this tendency is, at best, extremely weak, and there are many exceptions. (This, of course, could have been concluded also from the data on incremental capital-to-output ratios given in column (4) of table 1.) To those who are used to believe that output is linked in a direct way to capital accumulation, this surely is a remarkable finding. To me, diagram A is a very strong indication that capital cannot be the most important factor of growth. Diagram A, therefore, represents a challenge: We cannot, in light of this evidence, accept as valid a theory of growth which implies a close correspondence between the accumulation of capital and the rate of growth of output. I shall return to this point later on.

A final negative conclusion is that the variations in growth rates cannot be traced back to the way in which investment has been distributed in different countries. It has sometimes been suggested, for instance, that the high incremental capital to output ratio of some countries is a result of their concentration of investment in capital-intensive industries. Nothing points to this conclusion. Again data show that, from country to country, the allocation of investment by industries varies surprisingly little⁷⁾.

These are some of the negative conclusions to be drawn from the ECE and the OECD studies. They have, however, also in a positive way contributed to our understanding of growth.

They suggest, for instance, that the gradual process of re-allocation of resources - the moving of labour and capital from industries where productivity is low (in particular agriculture) to industries where it is higher - may be an important factor of growth. It has been found, for instance, that such re-allocation gains may account for as much as 24 per cent of the growth achieved by Yugoslavia, some 15 per cent of the growth of Austria and Norway, some 10 per cent of that of Western Germany and Canada, but little or nothing in countries where opportunities for such gains were smaller, such as the Netherlands, the United States, Denmark, Belgium and Great Britain⁸⁾.

6) ECE study, Ch. II, Section 3. See also United Nation: World Economic Survey 1959.

7) ECE study, Ch. III, tables 13, A1, XXX and A9.

8) ECE study, Ch. III, Section 8.

Another finding worth nothing is that the growth of output during the 1950's has been most rapid in those countries where the labour force has increased most quickly, see diagram B. On average, a one per cent higher rate of growth of the labour force has been accompanied by a 1.4 per cent higher rate of growth of national product. If this could be interpreted as indicating a chain of cause-effect, we should have to conclude that a quickly growing labour force not only helps in promoting a high rate of growth of total output but - other things being equal - of output per man-year worked as well. Such a conclusion, however, I find hard to accept, and there is little to support it in data from earlier periods⁹⁾. Still, a cause-effect chain of this kind cannot be completely ruled out; it is possible, for instance, that a quickly growing labour force stimulates labour productivity by causing greater mobility on the labour market and hence greater opportunities for achieving re-allocation gains¹⁰⁾.

A third conclusion for which there is some evidence, is that a high level of demand creates a climate which is favourable to growth. It may be more than a coincidence that those countries whose growth records during the 1950's were comparatively poor are precisely those who - for longer periods - experienced unemployment because their levels of demand were insufficient, such as Great Britain, the United States, and Canada. In particular, a high level of foreign demand is likely to foster growth - directly, because it stimulates expansion in export industries, indirectly because it makes it unnecessary for the authorities to clamp down on internal demand in order to conserve foreign exchange. This idea, that a sufficient level of demand is an important pre-condition for growth, has been pushed particularly strongly by OECD¹¹⁾. I am prepared to accept its validity for shorter periods, but not necessarily for long-run developments.

9) On this, see a study by Miss Paige, Blackaby and Freund: *Economic Growth: The Last Hundred Years*. *Nat. Inst. Ec. Rew.* (National Institute of Economic and Social Research, London), July 1961. The authors conclude " ... there is not much evidence to support the commonly-held belief that a stable population is an important obstacle to growth", (p. 28).

10) ECE study, Ch. II, Section 2.

11) "The most general pre-condition for rapid economic growth is the existence of an adequate and sustained pressure of demand on the productive resources of the economy. Where this condition is fulfilled, there develop generally optimistic and dynamic attitudes among entrepreneurs and workers. In turn, the record suggests that the existence of such confident expectations about the possibility of disposing of additional output produces, in the event, rapid increases in productivity through their effects on investment, innovation and mobility" ... "it seems that producers' confidence in their ability to compete successfully with foreign producers - in their home or in foreign market - is a further necessary condition for rapid growth in countries which are heavily dependent on foreign trade." OECD study, pp. 17-18.

A last, and very important clue to our understanding, is a demonstration by the ECE that the observed rates of growth show a tendency to become more uniform the longer periods we consider¹²⁾. We have long been aware that the countries which have grown most rapidly during the 1950's are precisely those who were most severely hit during the war. The data reproduced in table 2 shows that the tendency for the growth rates to even out over longer periods becomes still more pronounced when the last three decades are seen as a whole. I find this observation most interesting. It may indicate that the growth trends over longer periods -- say 20-30 years and more -- are determined by other forces than those responsible for short-time developments. They may indicate, in other words, that there exists a mechanism which ensures, more or less automatically, that temporary set-backs are made good. This "catching-up hypothesis" is not weakened by the following calculation: Assume two countries having the same per-capita income today. If one grows steadily at 2 per cent a year and the other steadily 3 per cent, the latter, in 50 years time, would have achieved a per capita income more than double that of the former. That this could happen does not seem to me to be very likely in a world where all countries have access to the same technology, where a new process or invention can be copied elsewhere in a very short time¹³⁾.

4. The international growth race

However, that it has been possible in the past for a country to fall seriously behind, is illustrated by the graph C. This graph shows the growth-path of a few selected countries over the last hundred years.^{x)} It has been drawn by combining OECD data on per capita product levels in 1950 with national series of growth in such a way that the vertical axis measures per capita output in any country and any year as a percentage of UK per capita in 1950¹⁴⁾.

12) ECE study, Ch. II, pp. 3-4.

13) There remains, however, some doubt as to the amount of evidence to be found for the "catching-up hypothesis" in historical series. For instance, Miss Paige, Blackaby and Freund, though they do find, in the study already referred to, that set-backs caused by catastrophic wars and depressions are made good again to a considerable degree, nevertheless conclude: "Our series do suggest that growth is especially fast during the recovery period following a major interruption, but that, at least during the twentieth century, countries have never fully made up the ground they lost as a result of the cataclysms". (Nat. Inst. Ec. Rew., loc. cit, p.29).

x) The graph is not reproduced in this mimeographed note.

14) Data on 1950 per capita product level, were taken from Milton Gilbert and Associates: Comparative National Products and Price Levels, OEEC, Paris, 1958, using average European price weights. Series on product per capita growth for individual countries were compiled by the Central Bureau of Statistics of Norway by combining historical series on product and population taken from A Maddison: Economic Growth in Western Europe 1870-1957 (Reprint from Banca Nazionale del Lavoro Quarterly Review, Roma, March 1959) and linking them to figures for recent years as given in OECD publications.

(For example, when US passed the 100 per cent line in 1910 it had a per capita income equal to UK per capita income in 1950). It goes without saying that margins of errors of this graph must be very big, and I can only hope that, in its essential features, it is correct. If so, the vertical distance between two countries' curves would show their relative output levels at any point of time. The horizontal distance between two country curves will indicate how many years one country was behind or ahead of another for a given level of output.

The graph shows the United States at the top and Italy at the bottom, with Great Britain, Germany, Denmark, the Netherlands and Norway forming a complex pattern in between. - The graph invites many comments. For lack of time, I must restrict myself to some of the more noticeable features: (i) The comparatively steady long-term advance of US, temporarily interrupted only by the great depression. (ii) Great Britain, since 1870, gradually falling behind the United States with the result that she reached a level in 1940 which the US had passed 30-40 years earlier. (iii) The late start and slow growth of Italy up to 1940, and its spurt after 1950 to catch up with the rest. (iv) The tremendous set-back of Western Germany during the 60 years from 1890 to 1950. (v) The steady but never very strong advance of the two representatives for the Scandinavian countries, Denmark and Norway. (vi) The long-run parallellism of the curves, regardless of levels, which implies that the long-run growth rates have been about the same for all countries¹⁵⁾.

5. Trends within the theory of economic growth

Let us now turn to economic theory. What guidance has theory to offer?

Economic theory, by long tradition, considers the level of output (more precisely, potential output with full capacity utilization) to be determined partly by the size of the labour force, partly by the stock of capital available, and partly by the technological and organizational level to which the society has reached - the last determining how efficiently the labour and capital are combined.

In the early post-war years it was taken more or less for granted that, of the three, the stock of capital was crucial. Simplified models of

15) Interested readers will find a much more extended discussion on this, based on a similar technic of analysis, in the study by Miss Paige, Blackaboy and Freund referred to above. Their study includes data for a larger number of countries and also tries to appreciate the margins of errors involved in the comparison.

growth quite often postulated a direct proportionality between capital and output. That is to say, they postulated a constant incremental capital-to-output ratio and assumed that output in the long run would grow in step with (pari-passu) the capital stock, no more, no less. To the policy-maker this meant that higher investment levels - preferably "productive" investments - was the only way to quicker growth.

Since then, evidence has been mounting which has cast serious doubt on the validity of such simple theories. The idea that capital uniquely determines output is, for instance, hardly compatible with such observations as those reproduced in diagram A. Empirical studies of the past history of national economies, as data became available, were equally damaging. They showed, without exceptions, that only a part of the increased output per man of the last decades could be ascribed to increased input of capital, and suggested that productivity improvements - whatever their reasons - played a crucial role. Kendrick's work for the United States is typical of this line of research. He concluded that, for the period 1899 to 1957, increased inputs of labour and capital could explain only about one half of the growth of the national product. The other half was caused by other factors¹⁶⁾.

Such empirical findings have forced a re-orientation of growth theory. I believe it is generally accepted by now that growth models which assume "constant techniques" must necessarily be unrealistic, since they abstract from what is, perhaps, the crux of the process of growth. Instead, scholars have turned their interest to productivity itself. The front of research at present is concentrated on two issues: (i) To clarify the quantitative role of "technical advance" as a promotor of growth, and (ii) to find out which factors ultimately determine the rate of this advance.

6. The idea of an aggregate production function

One offshoot of this work has been attempts to design a growth formula - a production function - which will describe in quantitative terms the way in which the input of capital and labour, and the level of technique, determine the output potential of a society. One particularly popular formula, on which much work has been done, is the so called Cobb-Douglas production function

16) John W. Kendrick: Productivity Trends in the United States, Princeton University Press, 1961.

supplemented with a trend component¹⁷⁾. This function assumes that the growth rates of output ($\Delta O/O$), capital ($\Delta K/K$) and labour ($\Delta N/N$), measured as annual percentage increases, are related to each other through the relation

$$\Delta O/O = a \Delta K/K + b \Delta N/N + z$$

where a and b are constants and where z - a residual - can be taken to represent the annual percentage increase in output due to technical progress. It would take me too far afield here to give reasons why this formula may be a plausible one.

If we assume that z is a constant - this means assuming that technical progress advances at a constant rate over time - it is possible from historical records of output, labour and capital to estimate the constants of this formula (a , b and z) by econometric methods. To my knowledge, this has been done, so far, for four countries. The findings are compared in table 3.

At a glance, the results for the four countries are seen to be very close: On average, a 1 per cent increase of capital has been found to increase output by some 0.3 per cent; a 1 per cent increase of the labour force has increased output by about 0.7 per cent; and technical advance is found to have contributed between 1 and 2 percentage points to the annual growth of total output. Since the growth rate on average has been about 3 per cent, this means that about one half of total growth has been caused by technical improvements. Thus, the findings of Kendrick and others (referred to above) have been confirmed.

I might add that professor Tinbergen as long as twenty years ago found similar values for z for the much earlier period 1870-1914. Though the data on which his estimates are based, were, of course, much weaker than those we have available for more recent years, it is certainly not without interest to note his findings: For Germany $z = 1.5$ per cent, for Great Britain $z = 0.3$ per cent, for France $z = 1.1$ per cent, and for the United States $z = 1.1$. (Tinbergen underestimates the figure for Great Britain because he used too low a figure for output growth; had he used estimates now available he would have found $z = 1.3$ ¹⁸⁾).

17) The Cobb-Douglas production function with a trend component can be expressed as follows (O = output, K = capital, N = employment):

$$O = cK^a N^b e^{zt}$$

where c , a , b and z are constants. In terms of annual percentage changes this becomes

$$\Delta O/O = a \Delta K/K + b \Delta N/N + z$$

in which form the formula has been given in the text.

18) J. Tinbergen: Zur Theorie der langfristigen Wirtschaftsentwicklung, Weltw. Arch., 1942. Figures available to Tinbergen in 1942, for the period to which his study applied, showed a growth rate for Great Britain which was much too small, namely 1.6 per cent a year, whereas more recent information puts the rate at 2.6 per cent a year.

How do we interpret these findings? I am, personally, inclined to think that the formula points out an important feature of the growth process: That there is - always and everywhere - some important residual of growth which cannot easily be explained in terms of labour and capital. We must note, however, that all observations of z which we have, so far, relate to highly industrialized countries, and to periods when the growth of these countries was comparatively rapid. It is possible, therefore, that for other countries and other periods we shall find different values of z , both higher and lower.

I should point out, perhaps, that the growth theory represented by the Cobb-Douglas production function is consistent with the observed lack of constancy of the incremental capital-to-output ratio. In fact, the formula implies that the incremental capital output must vary: We should expect it to rise as investment rises, and to fall as investment falls. Furthermore, its level is higher when the investment increase is not accompanied by a corresponding increase in the labour force or in the rate of technical progress¹⁹⁾. This is as it should be: We would expect decreasing marginal returns on new capital unless this tendency becomes neutralized by a *pari passu* increase in labour or in technical progress.

7. Investment and technical progress

Before asking you to accept the formula as valid I have to strike one note of warning, however. The formula assumes, as it stands, that the rate of technical progress (z) is independent of the rate of growth of real capital ($\Delta K/K$). One may doubt the realism of this assumption and - in fact -

19) If formula (2) of footnote (17) holds, the incremental capital-to-output ratio ($\Delta K/\Delta O$) is

$$\frac{\Delta K}{\Delta O} = \frac{1}{O/\Delta K \left(b \frac{\Delta N}{N} + z \right) + a \frac{O}{K}}$$

Formula (3) shows that the incremental capital output ratio is not a constant; it will be higher the higher is the rate of investment ($\Delta K/O$) and the average capital output ratio and the lower is the rate of increase of the labour force ($\Delta N/N$) and the rate of technical progress (z).

it has been doubted²⁰⁾. We know that new technical ideas often - though not always - require new capital formation in order for these ideas to be put into practical use. We would expect, therefore, that a sudden "spurt" in the formation of new capital (a higher $\Delta K/K$) would be accompanied by a higher rate of technical advance (a higher z)²¹⁾. For this reason, our growth formula may tend to underestimate the effects which fluctuations in the rate of capital formation may have on output in the short run.

However, since such a spurt in investment implies an exhausting of available ideas and knowledge, its effect on growth would only be temporary. In the long run it is the ability of man to devise new technological possibilities, man's gradually increasing insight and cleverness alone, which determine the speed of technical progress, and this is so irrespective of whether the rate of capital accumulation is being kept permanently high or permanently low. In the long run, therefore, the relative weights which the formula gives to capital and technical progress may give a fair description of reality²²⁾.

8. The international league table - a second look

Equipped with this finding, let us have a second look at the international league table.

We have noted already that the countries which have done best in the 1950's are, without exception, either countries which experienced severe set-backs during the war, or countries which were hard hit during the great depression of the 1930's - and sometimes both. This fact makes it likely

20) Stemming from such criticism alternative models have been suggested where technological progress is made explicitly to depend on investment. For instance, it may be assumed that all technical progress is uniform and exponential over time, and that each "vintage" of capital at its moment of construction "embodies" all the latest knowledge but shares not at all in any further improvements in technology. If so, the level of technology of a country at a given date becomes a function of (among other things) its investment history in the past. The implications of this assumption was first worked out by Robert Solow in an article: "Investment and Technical Progress" (in Arrow, Karlin & Suppes (editors): Mathematical Methods in the Social Sciences, Stanford University Press, 1959). A revised version of the model is given in Solow: Technical Progress, Capital Formation, and Economic Growth, Am. Ec. Rev. (Proceedings) May 1962.

21) However, an attempt to trace this effect in data for US manufacturing over the period 1919-1958 proved inconclusive, see B.F. Massell: "Is Investment Really Unimportant?" Metroeconomica, Volume XIV (1962).

22) For a more extensive discussion on this see W.A. Eltis: Investment, Technical Progress, and Economic Growth, Oxford Ec. Papers, March 1963, and D. Hamberg: Investment and Economic Growth, Metroeconomica, April 1963.

that the exceptionally rapid growth of these countries represents, in the main, a "catching up" with earlier lost opportunities. In other words: It is probable that W. Germany, Greece, Italy and France - to some extent also Spain and Switzerland - have experienced strong growth in the 1950's mainly because their economies grew so slowly, or even dropped, during the preceding decade(s). But this "catching-up-hypothesis" cannot explain the comparatively slow growth in recent years of some other countries, such as Luxembourg, Great Britain and Ireland.

If we believe in the validity of our growth formula, we can use it to analyse in quantitative terms the causes of post-war growths for selected countries. It follows from formula (2) that, if a and b are given, the contribution of labour and capital to the growth of output can be computed when the growth rates of labour and capital are known. Then z may be found as a residual. The results are in table 4²³⁾. In deriving this table, a and b were put at 0.3 and 0.7 respectively - rounded averages of the values found in the four country studies reported in table 3. - The figures of table 4 relate to the 1950's as a whole, except for those countries whose economies in 1949 were obviously still heavily influenced by the aftermath of war. For these countries data are given by 5-year sub-periods. Israel and Japan have been included to illustrate development in two of the most rapidly growing economies of the world.

We can draw some interesting conclusions from this table - granted, of course, that we are not too doubtful about the growth theory from which the table is derived. It is seen from column (4), for instance, that the rapid increase of the labour force in such countries as Canada, the Netherlands and Western Germany explains about one percentage point or more of the growth rates of these countries. Compare this with the smaller contribution to growth of labour in France and Norway. Column (5) suggests that the slow growth of Belgium and Great Britain must be explained in part by the comparatively low growth effect of capital changes in these countries. Italy and France, on the other hand, have achieved high rates of growth with a similar moderate growth of capital.

For our purpose, however, it is column (6) which commands most interest.

23) Data for Israel, Japan and Norway in table 4 are estimates by the author. For other countries data are from the ECE study (Ch. II, table 18) except that for some countries (those which in the early 1950's might be suspected to have been still amidst a process of reconstruction) they were replaced by estimates by 5-year subperiods which ECE, at the authors request, gracefully undertook to make available.

The countries fall into three groups. The first - and biggest - group consists of those countries where - for the post-reconstruction period - estimates of the contribution of technical progress to growth is found to have been something like 1 to 2 per cent. They are

Canada (1949-1959)	0.7	Netherland (1949-1959)	1.6
United Kingdom (1949-1959)	1.2	Norway (1949-1961)	2.3
Belgium (1954-1959)	1.6	Sweden (1949-1959)	(2.5)

(I have included Sweden in this group, because the growth rate of capital for Sweden as given in the table - 2 per cent a year - appears so low that I suspect the estimate for z to be too high). These are figures which, from historical evidence, we may consider slightly better than average results for advanced, industrialized societies.

In the second group we find the three European "miracle countries" of the post war years, in this order: Italy, Western Germany, and France. For these countries the estimated contribution of technical progress, though it has been falling, as late as in the period 1954-1959 is as high as 2.8 to 4.1 per cent. These are exceptionally high figures for such prolonged period.

How high they are, becomes apparent when noting that they exceed even those of the third group, Israel and Japan - two dynamic economies who are still in the early stages of their process of industrialization and which, for this reason, have particular scope for growth.

Only two explanations seem possible: Either Italy, German and France accumulated growth potentialities in earlier periods - in the form of knowledge, insight or in other ways - which only during the 1950's have been fully released, or we must simply accept the recent developments in these countries as "an economic miracle".

10. The puzzling residual

There remains one question on which I have to comment, though I shall be brief.

We have sufficient evidence today to conclude, I believe, that there are important factors of growth - besides labour and capital - hiding behind the residual (z). We have referred to them in a loose way as "technical progress", "organization", "the human factor". What are these factors?

The only honest answer to this is, I believe, that we do not really know. I am tempted to go further: We may never know for sure. For how can we ever hope to determine the relative importance of the many factors which determine productivity, ranging from government economic policy to the competitive spirit of entrepreneurship?

Still, behind most of the factors which we could think of listing as contributing to productivity we shall find one thing: Improved human competence. And since human competence is a result of education, training and research, the presumption is strong that these are the factors on which technical progress ultimately hinges.

I could quote more direct evidence pointing in the same direction, notably research by American scholars which shows that the rate of return on investment in "human capital", however measured, may be at least as large as that on physical capital²⁴⁾. We have also the well known calculations by Edward F. Denison, reproduced in table 5. He is the only author I know of who has made the daring attempt to split up the residual by components: As will be seen, he concludes that education and research have been the most important contributor by far to the growth of the American economy over the last 30 years²⁵⁾.

I am tempted to conclude: If I were given the economic dictatorship of a country, charged with the task of ensuring a maximum rate of growth, I would be prepared to risk my posthumous fame by betting heavily on education and research - under the motto: "Mind over machine".

24) A useful survey of American research in this field is contained in "Investment in Human Beings" (Papers presented at a conference called by the Universities - National Bureau Committee for Economic Research) Journ. Pol. Ec., October 1962, No. 5, Part 2.

25) Edward F. Denison: The Sources of Economic Growth in the United States and the Alternatives Before Us (Committee for Economic Development), New York. 1962.

Table 1. Growth rates of gross national product and incremental gross capital-output ratios, 1950-1960.

	Growth rates of GNP			Incremental capital-output ratio 1)
	Total GNP	GNP per capita	GNP per employed	
	(1)	(2)	(3)	(4)
Western Germany	7.5	6.4	5.2	3.3
Austria	6.1	5.9	5.8	3.9
Italy	5.9	5.4	4.3	3.7
Netherlands	4.9	3.6	3.4	5.2
France	4.3	3.4	3.9	4.6
Canada	3.9	1.2	1.9	6.0
Norway	3.5	2.5	3.2	9.5
Denmark	3.3	2.6	2.5	5.5
United States	3.3	1.6	2.1	5.5
Sweden	3.2	2.6	2.9	6.3
Belgium	2.9	2.3	2.5	5.6
United Kingdom	2.6	2.2	2.0	6.7
Luxembourg	2.1	1.5	1.2	6.2
Ireland	1.4	1.9	2.5	13.7
Average 14 countries	3.9	3.1	3.1	6.1
Greece	6.2	5.3	..	3.0
Turkey	5.8	2.9	..	2.6
Switzerland	5.1	3.7	..	4.5
Spain	4.9	4.1	..	3.1
Iceland	4.8	2.7	..	5.7
Portugal	3.9	3.2	..	4.0
Average 20 countries	4.1	3.2	..	5.4

Sources: Column (1) and (3): OECD: Policies for Economic Growth, Paris 1962, table 1. Column (2): Computed by Central Bureau of Statistics of Norway. Column (4): United Nations: Economic Survey of Europe 1961, Part II, table 6.

1) 1949-1959.

Table 2. Growth of output in western countries 1929-1959. (Compound annual percentage rates of growth of national product at constant prices).

	1929 to 1939	1939 to 1949	1949 to 1959	1929 to 1959 (average (1)-(3))
	(1)	(2)	(3)	(4)
Turkey	3.7	1.8 ^{a)}	5.9	3.8
Canada	0.6	5.5	4.2	3.4
W. Germany	4.3	-2.2	7.4 ^{b)}	3.2
Sweden	3.0	3.0 ^{c)}	3.4	3.1
Norway	3.2	2.4	3.4	3.0
Finland	3.1	1.6	4.2	3.0
Yugoslavia	1.7	1.5	5.5	2.9
United States	0.6	4.4	3.3	2.8
Italy	1.6	0.1	5.9	2.5
Netherlands	0.4	2.3	4.8	2.5
Denmark	2.5	1.5	3.2	2.4
Switzerland	-0.1	1.5 ^{d)}	5.2	2.2
Austria	-0.6 ^{e)}	0.8 ^{c)}	6.0	2.1
United Kingdom	2.2 ^{f)}	1.0 ^{c)}	2.4	1.9
Ireland	1.1	2.3	1.3	1.6
Spain	-1.7 ^{g)}	1.1 ^{h)}	5.2	1.5
France	-1.1	0.2	4.5	1.2
Belgium	-0.2 ^{f)}	0.6 ^{c)}	3.0	1.1
Luxembourg	3.8	..
Greece	..	-2.0 ^{d)}	5.9	..
Iceland	5.4 ^{b)}	..
Portugal	4.1	..

Source: United Nations: Economic Survey of Europe 1961, Part II, table 2.

- a) 1938 to 1948
- b) 1950 to 1959
- c) 1937 to 1949
- d) 1938 to 1949
- e) 1928 to 1937
- f) 1929 to 1937
- g) 1929 to 1940
- h) 1940 to 1949

Table 3. Estimates of the coefficients of the Cobb-Douglas production function with a trend component for four countries.

	a (Per cent increase of output by 1 per cent increase of capital)	b (Per cent increase of output by 1 per cent increase of labour)	(Per cent increase of output by 1 per cent increase of imports)	z (Trend, ascribed to technical progress)
Norway (1900-1955)				
(Total economy)	0.20	0.76	..	1.8
United States (1909-1949)				
(Private non-farm activity)	0.35	0.65	..	1.5
Finland (1925-1952)				
(Industry)	0.26	0.74	..	1.2
W. Germany (1925-1957)				
(Total economy)	0.34	0.76	0.23	1.9

Sources: Odd Aukrust and Juul Bjerke: Real Capital and Economic Growth in Norway 1900-56, in Goldsmith and Saunders (editors): Income and Wealth Series VIII, London 1959; Robert Solow: "Technical Change and the Aggregate Production Function", Rev. Ec. Stats., August 1957; Olavi Niitamo: "Tuottavuuden Kehitys Suomen teollisuudessa vuosina 1925-1952", Helsinki 1958; Gerhard Gehrig and Karl Christian Kuhlo: Ökonometrische Analyse des Produktionsprozesses, IFO-Studien, 7. Jahrgang 1961, Heft 1/2. In the study for Western Germany output was measured as national product + exports, and imports correspondingly included on the right-hand side as a separate factor of production, symmetrically with K and N.

Note: If O = output, K = capital, N = employment the Cobb-Douglas production function with a trend component can be expressed as follows

$$O = c K^a N^b e^{zt} \quad (1)$$

where c , a , b and z are constants, or in terms of annual percentage changes as

$$\frac{\Delta O}{O} = a \frac{\Delta K}{K} + b \frac{\Delta N}{N} + z \quad (2)$$

If (2) holds, the incremental capital to output ratio ($\Delta K/\Delta O$) is

$$\frac{\Delta K}{\Delta O} = \frac{1}{O/\Delta K (b \frac{\Delta N}{N} + z) + a \frac{O}{K}} \quad (3)$$

Formula (3) shows that the incremental capital output ratio is not a constant; it will be higher the higher is the rate of investment ($\Delta K/O$) and the lower is the rate of increase of the labour force ($\Delta N/N$) and the rate of technical progress (z).

Table 4. The estimated contribution to growth of gross domestic product (GNP) of increases of labour force, capital stock and "technical progress" in selected countries.

Country and period		Annual rates of growth of			Estimated contribution to growth of		
		Labour	Capital	G.N.P.	Labour	Capital	"Technical progress"
		(1)	(2)	(3)	(4)	(5)	(6)
Belgium	1949-1954	0.6	2.4	3.6	0.4	0.7	2.5
	1954-1959	-0.1	2.7	2.3	-0.1	0.8	1.6
Canada	1949-1959	2.1	7.1	4.3	1.5	2.1	0.7
Netherlands	1949-1954	1.4	4.0	4.9	1.0	1.2	2.7
	1954-1959	1.1	5.5	4.1	0.8	1.7	1.6
Norway	1949-1959	0.2	4.4	3.7	0.1	1.3	2.3
Sweden	1949-1959	0.5	2.0	3.4	0.3	0.6	2.5
United Kingdom	1949-1959	0.6	3.1	2.5	0.4	0.9	1.2

France	1949-1954	0.1	2.9	4.8	0.1	0.9	3.8
	1954-1959	0.2	3.9	4.1	0.1	1.2	2.8
Italy	1949-1954	1.5	3.0	6.4	1.1	0.9	4.4
	1954-1959	0.8	3.4	5.7	0.6	1.0	4.1
W. Germany	1950-1954	1.8	4.8	8.3	1.3	1.4	5.6
	1954-1959	1.4	6.9	6.6	1.0	2.1	3.5

Israel	1952-1958	3.3	11.8	9.8 ¹⁾	2.3	3.6	3.9
Japan	1950-1958	2.4	10.6	7.9	1.7	3.2	3.0

Source: Table in manuscript from ECE except for Norway, Israel and Japan, where figures have been computed by the Central Bureau of Statistics of Norway.

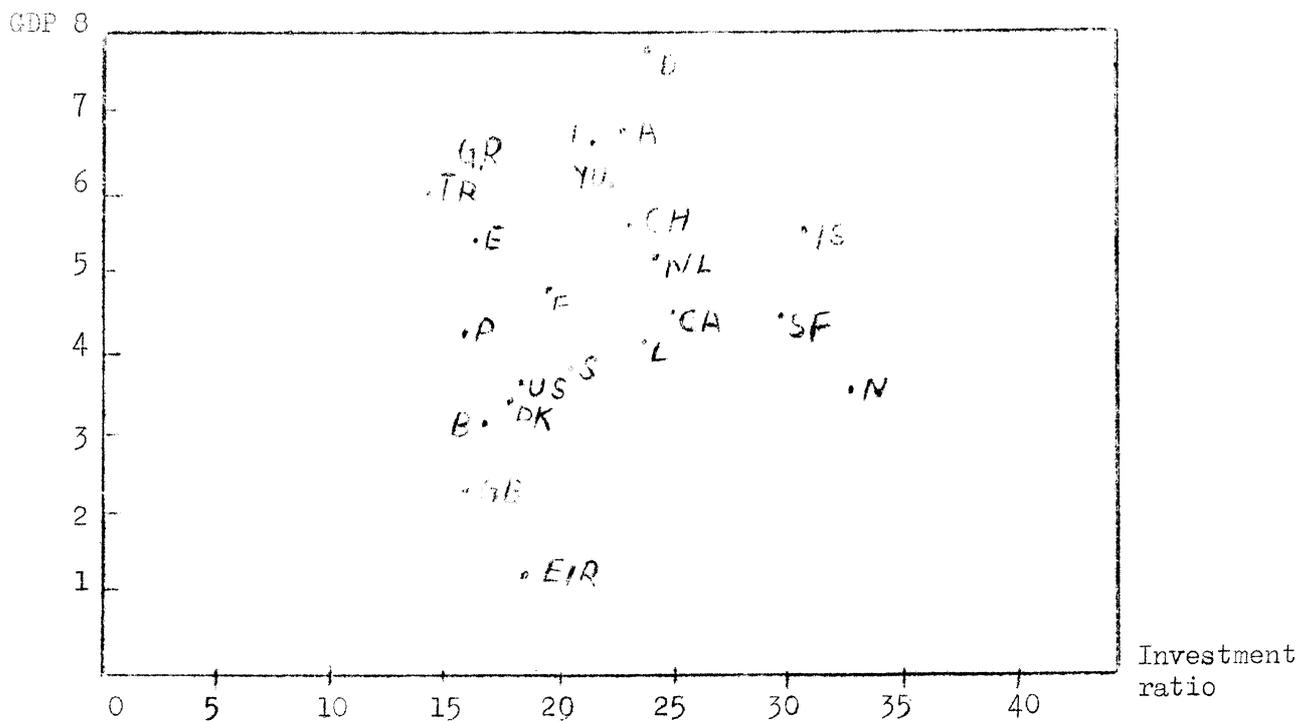
1) Net national product.

Table 5. Allocation of Growth Rate of Total Real National Income Among the Sources of Growth 1929-1957.

	<u>Percentage points in growth rate</u>	
Increased employment (net effect of more man-years, shorter hours, and changes in composition of labour force)		0.90
Increased use of capital		0.43
Education and research:		
Better educated labour force	0.67	
Advance of knowledge	<u>0.58</u>	1.25
Economies of scale:		
Growth of national market	0.27	
Independent growth of local markets	<u>0.07</u>	0.34
Other factors:		
Change in lag of application of knowledge	0.01	
Reduced waste of labour in agriculture	0.02	
Industry shift from agriculture	0.05	
Restrictions against optimum use of resources ..	<u>-0.07</u>	<u>0.01</u>
	Total growth rate	<u>2.93</u>

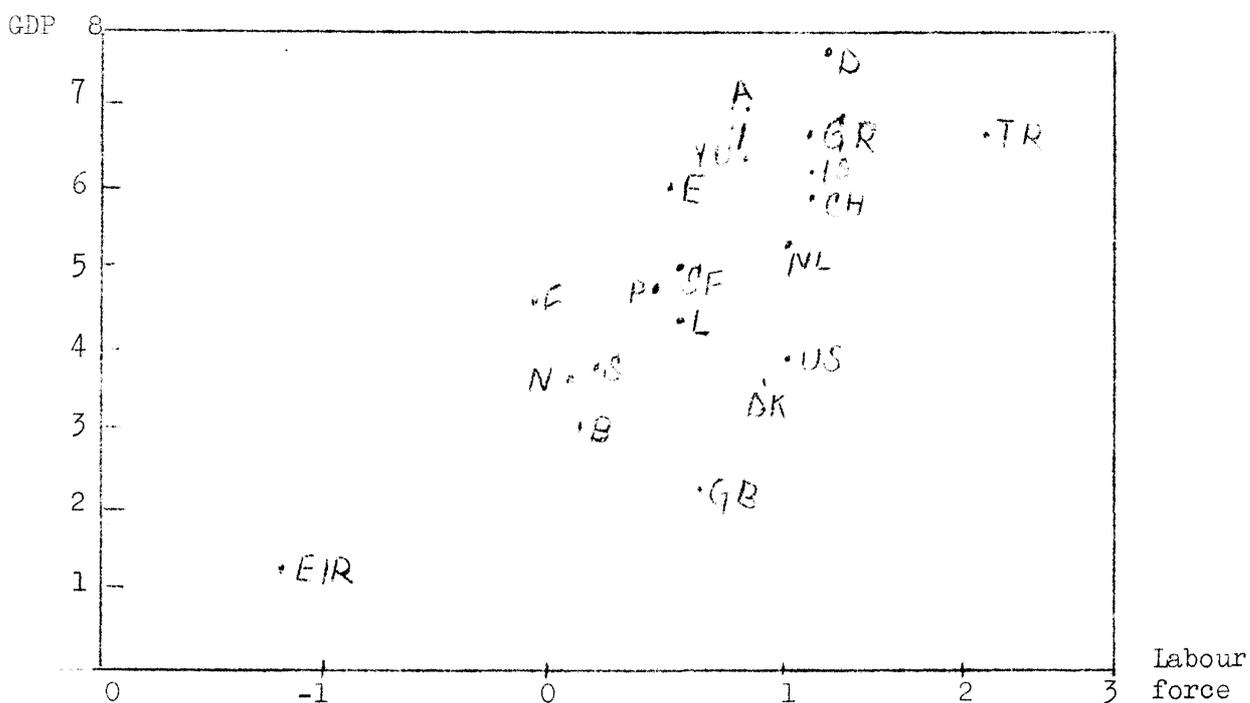
Source: Edward F. Denison: The Sources of Economic Growth in the United States and the Alternatives before Us (Committee for Economic Development), New York 1962, p. 266. (Data are reproduced here in rearranged form).

Diagram A: Percentage rates of growth of domestic product and investment ratios in western countries, 1949 to 1959.



Source: ECE

Diagram B: Percentage rates of growth of domestic product and of labour force in western countries, 1949 to 1959.



Source: ECE