INTERNATIONAL STUDIES OF FACTOR INPUTS AND TOTAL FACTOR PRODUCTIVITY: A BRIEF SURVEY

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This paper summarizes the results of several studies on total factor productivity of twenty-five countries over the period 1950–1965. Some methodological issues which underlie the derivation and calculation of the familiar partial and total factor productivity indices are discussed. Though evidence on labor productivity for a large number of countries is presented and discussed, the main thrust of the discussion is in terms of the determinants of *total* factor productivity. The quantitative and qualitative contributions of labor and capital to growth of income are assessed with special attention to the contrasting patterns of these contributions among developed and developing economies. The problems of acceleration and retardation of the growth rate of some economies are considered and possible explanations are offered. Variations in the magnitude and sectoral distribution of the growth rates in several countries over this period are examined. Finally, areas for further research in comparative economic growth are suggested.

INTRODUCTION

Changes in productivity are the result of the dynamic interaction between diverse and continually changing forces in an economy. The relationships between forces such as accumulation of human and physical capital, technical change, institutional changes, etc. are complex and difficult to categorize simply. The problem becomes even more complex when the growth patterns of several countries are considered. However, the importance of the issues requires, and justifies, attempts to quantify the sources of growth in different economies. My purpose here is to focus on a number of such attempts—several studies of total factor productivity during the postwar period for a select number of countries. The discussion is addressed to three major issues:

(a) the role of quantity and quality of conventional inputs, with particular emphasis on education, on growth of output;

(b) the reasons for the acceleration and retardation of growth in some countries considered here; and

(c) the importance of resource reallocation in the growth process.

It seems important to call attention to a number of issues which have necessarily been excluded. First, I have not dealt with long-term studies of factor productivity because (a) they are well discussed by Aukrust [1], Paige, Blackaby and Freund [36], Maddison [34] and others, and (b) several new studies pertaining to the long-term growth experience of several industrialized countries are currently under way as part of the S.S.R.C. project.[1] Second, the discussion is confined to materials covering mainly the period 1959–1962. Thus, some of

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[1]They include studies of economic growth in France, Japan, Sweden, U.K., West Germany, and the U.S.

the results reported here may no longer be valid.[2] Third, attention is primarily devoted to the growth accounting approach underlying the work of Abramovitz, Fabricant, Kendrick and Denison. No attempt is made to cover the studies based on estimation of production functions [35a]. Nor have I discussed studies related to short-run productivity changes (employment functions). Fourth, the emphasis is on the determinants of growth as affected by supply; there is very little discussion of effective demand as a determinant of factor productivity.

The plan of the paper is as follows. In Section I, some methodological issues are briefly discussed. Some quantitative evidence on labor productivity and total factor productivity indices for a number of countries is presented and briefly discussed in Section II. Section III contains a discussion of contributions of each factor to growth of income and the sources of total factor productivity. The problems of growth retardation of some economies and variations in the magnitude and sectoral distribution of the growth rates are discussed in Section IV. Section V concludes the paper with some suggestions for further research.

I. Measurement of Factor Productivity and Some Conceptual Problems

A. Alternative Measures

Productivity is usually measured as a ratio of output to inputs. There are, therefore, at least as many indices of productivity as there are factors of production. While each index has its own use, the most important and most often used are the *partial* productivity indices of labor and capital and the *total or multifactor* productivity index. The former indices are simply the average products of labor, or capital, while the total factor productivity index, often referred to as the "residual" or the index of "technical progress," is defined as output per unit of labor and capital combined.

(a) Partial indices:

$$AP_L = Q/L; \qquad AP_K = Q/K; \tag{1}$$

(b) Total productivity index:

$$A = Q/(aL + bK)$$

where Q, L, and K are, respectively, the aggregate level of output, labor, and capital inputs; a and b are some appropriate weights.

There are many ways of measuring growth of total factor productivity, but the two indices most often used in empirical research are Kendrick's arithmetic measure [26], and R. Solow's geometric index [39].

Kendrick measures total factor productivity using a distribution equation derived from a homogeneous production function and the Euler condition. That is—

$$\frac{dA}{A} = \frac{Q_1/Q_0}{(wL_1 + rK_1)/(wL_0 + rK_0)} - 1 \tag{1a}$$

[2]For a recent study on comparative productivity of the U.S. and the Soviet economies see Bergson [2a].

where w and r are the wage rate and the rate of return on capital respectively, variables with the subscript 1 refer to the current period and those with the subscript 0 refer to the base period. In empirical estimates the weights for calculating (1a) are often permitted to change smoothly over time [28].

Solow's measure is based on the Cobb–Douglas production function, with constant returns to scale, autonomous and neutral technological change, and perfect competition, i.e.,

$$\frac{dA}{A} = \frac{dQ}{Q} - \left[\alpha\frac{dL}{L} + \beta\frac{dK}{K}\right]; \qquad \beta = (1 - \alpha) \tag{1b}$$

where α and β are the shares of labor and capital, and dQ, dL, and dK are the time derivatives of Q, L, and K. This measure is equivalent to Kendrick's index for *small* changes in the quantities of inputs and outputs [32].

The problem of estimating the sources of factor productivity using these indices becomes highly complicated if some of the simplifying assumptions are relaxed. Complications arise due to the difficulty of isolating the technical bias from disembodied technological change, movements of the elasticity of substitution, economies of scale, nonhomotheticity of the underlying production functions, and the embodiment effects. These attributes are not independent of one another, nor do they remain constant over time. To get reliable estimates of these sources of productivity change, even with the best estimation techniques, would require data that are much more accurate and detailed than any presently available.

B. Denison's Growth Accountancy Approach

An alternative approach towards isolating the contribution of the various factors to the growth of output is provided by Denison, in which the production function is used as an organizing device or an accounting format. Denison has made adjustments to convert the conventional factors of production to effective measures of labor and capital input and attribute the "residual," i.e., the growth of factor productivity, to economies of scale, resource reallocation and finally, "advancement of techniques."

The underlying relation between growth of output and the various explanatory factors is:

$$dQ = \mu\left[\sum_{i=1}^{n} \alpha_i dX_i + \sum_{j=1}^{m} y_j + J\right]$$

where dQ is the growth rate of national income valued at constant prices, μ is a measure of economies of scale, α_i refer to shares of the factors represented by dX_i and y_j are the growth rates of various disequilibrium factors.[3] Denison specifies dX_i ($i = 1 \ldots 7$) as the changes in employment, composition of employment, level of inventories, nonresidential land, nonresidential structures and equipment, quantity of dwelling and residential land, and the quantity of international assets. y_j refers to adjustment factors due to sectoral misallocation of

[3]This relationship is adopted from a mimeographed paper which Mr. Denison kindly sent me [14]. A very useful and similar index of total factor productivity has also been developed by Z. Griliches [18].

resources, institutional restrictions, inadequacy of aggregate demand, economies of scale, lags in the adoption of best-practice techniques, and difficulties in the dissemination of knowledge. Finally, J is the residual after the total contributions of dX_i and y_j are deducted from dQ.

It should be noted, however, that Denison is not committed to any fixed pattern of adjustments, i.e., the number and magnitudes of α_i, dX_i, and y_j are allowed to vary over time, as well as from one country to another, depending on the prevailing conditions.

In his empirical computations, Denison first takes account of the changes in employment, hours worked, the age–sex composition, and the education of the labor force. Combining all four aspects, and using earnings as weights, he calculates the contributions of quantitative and qualitative increases of labor input to growth of output. Capital is divided into four types; nonresidential structures and equipment, inventories, housing, and international assets. This classification is based on the premise that rates of return on different types of capital should be used to compute the contribution of each type to the growth of output.

The main sources of factor productivity are then attributed to resource reallocation, economies of scale and the contribution of advances in knowledge. The sum total of these adjustments would be approximately equivalent to the dA/A left unexplained by most other studies of factor productivity—assuming that their adjustments for quality of inputs were analogous to those of Denison.

C. Some Methodological Issues

Estimates of factor productivity are highly sensitive to the methods used for measuring real factor inputs and the exact classification of the quantity and quality of each input into its various elements. Only some of the main controversial issues are touched upon here.

In measuring the contribution of labor to growth of income, the main issues are: (i) the nature of the adjustments of labor input for health and nutritional conditions of the labor force, disequilibrium due to underemployment, age–sex composition and hours worked; (ii) more importantly, the role of educational attainment of the labor force in increasing its productivity.

As for the contribution of capital, three issues that have been the subject of controversy are: (i) the problem of capital stock valuation; (ii) adjustment of the capital stock for incomplete utilization; (iii) measurement of errors due to bias in the capital stock deflators.

There is agreement on the principle of adjusting employment data for changes in hours worked, underemployment, age–sex composition, and health and nutritional characteristics of the labor force. The difficulty arises regarding the relative importance of these elements in any given economy, and the availability of necessary data. Health and nutritional characteristics of the labor force and disguised unemployment certainly affect the quantity and quality of labor services dramatically in LDC's. Underemployment is also very important in countries with dualistic structures, e.g., Japan, Italy and the Eastern European economies.

There is considerable disagreement on how to assess and measure the contribution of education to growth of income. This is due partly to conceptual and partly to measurement problems. The conceptual issues are: (a) education is both an investment as well as a consumption good; (b) it interacts with other attributes of labor, i.e., labor participation, skill, preference between hours of work and leisure, and even the rate of population growth; (c) the quality of education is difficult to measure; and finally, (d) there are certain externalities associated with education. These conceptual issues make the measurement of the contribution of education a challenging but hazardous task: it is difficult to measure the return on education and estimate the stock of human capital. Isolating the effects of ability, schooling, and learning on the job, and of maintenance and net additions to the stock of education capital, is extremely difficult and subject to wide margins of error. Utilization of the stock of human capital, especially in LDC's, is an important problem. Currently active research is being undertaken in all these areas. Nonetheless, there is general agreement that improvement in educational attainment of workers does contribute positively to growth of income, and the labor input in most studies reported below has been adjusted for this factor.

The valuation problems in measuring capital stock are too well-known to necessitate a long discussion. Whether capitalized future yields, original costs or current market price of the assets should be used is still a matter of debate. But the ease and availability of data has forced many researchers to use the least desirable approach—the original cost method. The choice between net or gross capital and the treatment of capital stock of the public sector are still controversial issues. A more important problem is that of the distribution of the earnings of unincorporated establishments between entrepreneurs' labor and capital. The share of capital and hence its contribution to growth is often sensitive to the exact distribution used.

Another controversial issue is whether capital stock should be adjusted for under-utilization. The appropriate measure of capital input is capital services and not capital stock, which may include idle capacity. This problem is basically due to disequilibrium phenomena and, of course, does not arise in the long run. Recent controversy seems to center upon *what* measure of utilization rate is most appropriate. Jorgenson–Griliches [23] and Christensen and Jorgenson [8] have shown that total factor productivity is quite sensitive to the index of utilization used for this purpose.[4] Another measurement problem arises from the fact that investment deflators are not output but input price indices and therefore, biased upward. This bias affects contribution of capital to growth and the problem is one of choosing a deflator which is more appropriate than others ([22], [13]).

With these conceptual and measurement problems in mind, let us now turn to the empirical estimates of factor productivity in several countries during the postwar period. We shall first present some evidence on labor productivity

[4]In their original work [22], Jorgenson and Griliches, by making adjustments for biases in price deflators and especially for utilization rate, claimed to have reduced the residual to almost nothing. This conclusion has been revised drastically by the authors [23] based on the work of Christensen and Jorgenson [8] who show that with the use of an alternative measure of utilization (and some other minor adjustments) the residual turns out to be 0.31 instead of their earlier estimate of 0.10.

in a number of countries and then go on to report results for total factor productivity for another subset of countries. We are mainly interested in the latter indices and will discuss in some detail the contributions of different components of real factor input in Section III.

II. The Postwar Growth of Labor and Total Factor Productivity

A. Index of Labor Productivity: a Digression

The labor productivity index (1) has often been used as a measure of the performance of an economy or industry. It is a useful index and, due to the absence of capital stock data for many economies or industries, is generally the most easily available. The rise in this index may be due to increases in the quality of labor, technical progress, and increases in capital stock. In Table I the indices of labor productivity for several countries, most European, are shown.

Several aspects of these statistics should be noted: (i) in each country where data are available, growth rates in the industrial sector are higher than labor productivity at the national level. This may suggest that in the agricultural and/or service sectors there was a tendency for labor productivity to decline; (ii) the dispersion of labor productivity across countries is considerable and the level of these indices is generally very high, with a few exceptions such as the U.S., Canada, New Zealand and the Philippines; (iii) the highest rate of growth of over 9 per cent per annum is experienced by three Asian countries, Japan, Korea and Taiwan. The rates of growth of nonmarket economies are also generally higher than those of the Western economies. This difference would, however, probably be much smaller if adjustments were made for the differences in the measurement of output in the two types of economies.

B. Total Factor Productivity: an Over-all View

Though partial productivity indices are of interest, they are not as useful as the total factor productivity index. In Table II, the contribution of labor and capital inputs, total factor productivity, and growth rates of income for twenty-five countries and the State of Hawaii are presented. The specifics of calculating the contribution of each input will be discussed in the next section. At present we consider some of the over-all features of the results in this table.

(i) The growth rates vary considerably, from a low rate of 2.29 for the U.K. to 11.01 for Israel, and the countries seem to cluster in terms of growth rates. Four such groups can be distinguished, ranging from the extremely fast growing economies, with 9 per cent and above, to those below 4 per cent:

Groups	*Countries*
9%+	Israel, Japan
6%–9%	Venezuela, Germany, USSR
4%–6%	Italy, Greece, Philippines, Netherlands, Canada, all Latin American countries (except Argentina)
2%–4%	Argentina, Belgium, Denmark, Norway, U.K., and U.S.

TABLE 1

AVERAGE ANNUAL PERCENTAGE RATES OF GROWTH IN LABOR PRODUCTIVITY IN VARIOUS COUNTRIES[a]

Country	Period	National	Industry
	EUROPEAN COUNTRIES		
Austria	1956–1968	0.045	0.047
Belgium	1957–1966	0.032	0.050
Finland	1956–1968	0.037	0.044
France	1959–1968		0.054
Germany	1956–1968	0.041[b]	0.049
Ireland	1958–1967	0.040	0.048
Italy	1956–1967	0.062[b]	0.065
Netherlands	1958-1968	0.067	
Norway	1956–1968	0.036	0.042
Spain	1960–1968		0.083
Sweden	1956–1967		0.068[b]
United Kingdom	1956–1968	0.025	0.033
Bulgaria	1956–1968		0.060
Czechoslovakia	1956–1966		0.049
Hungary	1956–1967		0.053
Poland	1956–1966		0.060
Rumania	1956–1966		0.094
USSR	1958–1968		0.054
Yugoslavia	1956–1967		0.052[b]
	ASIAN COUNTRIES		
China (Taiwan)	1958–1966	0.064	0.101
Israel	1958–1968	0.051	0.057
Japan	1957–1967	0.088	0.093
Korea (South)	1960–1968		0.105
New Zealand	1956–1966	0.022[b]	0.031
	NORTH AMERICA		
Canada	1956–1968	0.026	0.037
United States	1956–1968	0.027	0.032

Source: International Labor Organization, *Measuring Labor Productivity* [21].

[a]Note that labor input is not adjusted for changes in hours and quality; it is measured by the number of employees. Moreover, the definitions of output and inputs differ substantially from one country to another, particularly the concept of output used in market economies as compared to that in nonmarket economies.

[b]Net production per person employed.

All rates of growth in Table II are very high compared to their long-run trends and in most countries are higher than in the U.S. This is due not to a lower growth rate in the U.S. economy but to the acceleration of growth in these economies.

(ii) Generally the growth rates of contribution of capital input and the rates of growth of factor productivity and national income are positively related. In some countries, a low rate of growth of labor contribution is associated with high rates of growth of income, factor productivity and contribution of capital. The

TABLE II

ALLOCATION OF THE SOURCES OF GROWTH OF REAL NATIONAL INCOME
SELECTED COUNTRIES AND STATE OF HAWAII[a]

Country	Period	Explanation of Sources of Growth			
		Labor Input	Capital Input	Increase in Output Per Unit of Input	Rate of Growth of Income
Argentina	1950–1962	1.58	1.43	0.18	3.19
Brazil	1950–1962	2.44	1.66	1.39	5.49
Chile	1950–1962	1.05	0.32	2.83	4.20
Colombia	1950–1962	2.35	1.04	1.40	4.79
Ecuador	1950–1962	1.47	1.07	2.18	4.72
Honduras	1950–1962	2.17	0.95	1.40	4.32
Mexico	1950–1962	2.41	2.82	0.74	5.97
Peru	1950–1962	1.40	1.40	2.83	5.63
Venezuela	1950–1962	2.59	2.04	3.11	7.74
Belgium	1950–1962	0.92	0.41	1.87	3.20
Denmark	1950–1962	0.91	0.96	1.64	3.51
France	1950–1962	0.51	0.79	3.62	4.92
Germany	1950–1962	1.88	1.41	3.97	7.26
Italy	1950–1962	1.10	0.70	4.16	5.96
Netherlands	1950–1962	1.00	1.04	2.63	4.73
Norway	1950–1962	1.51	0.89	2.05	3.45
U.K.	1950–1962	0.76	0.51	1.02	2.29
U.S.	1950–1962	1.41	0.83	1.08	3.32
Canada	1950–1962	1.50	1.20	2.10	4.80
Greece	1951–1961	2.80	1.63	0.86	5.68
Hawaii	1950–1960	1.76	1.77	1.66	5.20
India	1950–1960	1.86	1.55	1.06	4.48
Israel	1950–1965	3.50	4.10	3.40	11.00
Japan	1952–1967	2.45	4.49	2.03	9.42
Philippines	1947–1965	2.24	1.01	2.50	5.75
U.S.S.R.	1950–1962	1.33	3.15	1.82	6.30

Sources:

1. Latin American Countries, Correa [11], p. 27, Table 9.
2. Western European Countries and U.S., Denison [12], Tables 21-1 to 21-10.
3. Canada, Walters [44], p. 37, Table 15.
4. Israel, Gaathon [16], p. 205, Table A-13.
5. Japan, Chung [9], p. 239, Table 10-1.
6. U.S.S.R., Boretsky [4], p. 212, Table 8.
7. Philippines, Lampman [31], p. 182, Table 7.
8. Greece, Voloudakis [42], p. 48.
9. India, Psacharopoulos [37], p. 68, Table 32.
10. Hawaii, Psacharopoulos [37], p. 68, Table 32.

Note: The labor input figures are exclusive of adjustments for hours worked and age-sex composition of the labor force. The figures for Latin American and Western European countries and U.S. include adjustment for health and nutrition and were estimated by Correa [11].

contributions of both labor and capital inputs are smaller in the Western European countries and the U.S. than in the other countries. The contribution of capital is very high in the fast growing economies of Israel, Japan and the U.S.S.R.

(iii) The factor productivity seems to be lower in the developing countries, generally falling below 50 per cent of the growth rates of the economy. This may be partly because most of these economies devote a larger share of their output to infrastructure expenditures, with long-run increases in output, and partly due to the short-run difficulties of these economies in increasing the skill and quality of their human resources.[5]

A note of caution is in order. The data used to calculate factor productivity indices are often subject to error, especially in the developing countries. The definitions of the output and inputs are seldom comparable and therefore inter-country comparisons of economic performances should be made with considerable caution.

III. Contributions of Inputs to Growth of Income and Sources of Factor Productivity

The estimates of Table II depend critically on how the contributions of capital and labor are calculated. The conceptual problems associated with these measurements were touched upon earlier. In Tables III and IV the contribution of various components of labor and capital inputs is presented. Such a disaggregation is a necessary step toward an understanding of the sources of growth. The contribution of each element shown in these tables is calculated along the lines of Kendrick–Denison's approach. For some countries all the desirable adjustments have not been reported due to a lack of necessary data.

A. Labor Input

The contribution of the labor input is subdivided into five categories: employment, health and nutrition, working hours, age–sex composition and the educational attainment of the labor force. In Table III, the contributions of each of these factors, both in terms of its annual rate of growth and as a percentage of growth of national income, are indicated. The usual procedure is to weight changes in each of these elements by earnings as measures of marginal productivity, and to calculate their contribution to growth of income. Examination of the table suggests the following observations:

(a) The number of persons employed is an important source of growth of income in both rapidly developing advanced countries—Israel and Japan—as well as a number of Latin American countries and the Philippines. The exceptionally small contribution of employment in Chile, Peru and Greece is therefore remarkable and possibly biased downward. Among the industrialized countries its contribution is fairly large, about 20 to 30 per cent of the rate of growth of

[5]Note that these estimates vary substantially dependent on the underlying data and method used. For example, Bowles' [3] estimates for Greece of the contributions of labor and capital and factor productivity were 0.60, 2.44 and 0.86 respectively, sharply different from those indicated in Table 1, yet with the same rate of growth of output over the same period of time.

TABLE III

CONTRIBUTION OF LABOR INPUT TO ECONOMIC GROWTH OF VARIOUS COUNTRIES

Countries	Employment		Health and Nutrition		Working Hours		Age-Sex		Education		Total Labor Excluding Hours and Age-Sex		Total Labor Including Hours and Age-Sex	
	Rate	Per Cent	Rate	Per Cent	Rate	Per Cent	Rate	Per Cent	Rate	Per Cent	Rate	Per Cent	Rate	Per Cent
Argentina	0.93	29.03	0.12	3.76	n.a.	n.a.	n.a.	n.a.	0.53	16.49	1.58	49.33	n.a.	n.a.
Brazil	1.83	33.27	0.43	7.87	n.a.	n.a.	n.a.	n.a.	0.18	3.33	2.44	44.47	n.a.	n.a.
Chile	0.65	15.46	0.20	4.70	n.a.	n.a.	n.a.	n.a.	0.20	4.78	1.05	24.94	n.a.	n.a.
Colombia	1.66	34.75	0.49	10.21	n.a.	n.a.	n.a.	n.a.	0.20	4.13	2.35	49.09	n.a.	n.a.
Ecuador	0.92	19.53	0.32	6.77	n.a.	n.a.	n.a.	n.a.	0.23	4.93	1.47	31.23	n.a.	n.a.
Honduras	1.06	23.46	0.82	18.44	n.a.	n.a.	n.a.	n.a.	0.29	0.48	2.17	48.38	n.a.	n.a.
Mexico	1.43	23.96	0.93	15.66	n.a.	n.a.	n.a.	n.a.	0.05	0.83	2.41	40.45	n.a.	n.a.
Peru	0.67	11.97	0.57	10.50	n.a.	n.a.	n.a.	n.a.	0.14	2.53	1.40	25.00	n.a.	n.a.
Venezuela	2.19	28.34	0.21	2.72	n.a.	n.a.	n.a.	n.a.	0.19	2.41	2.59	33.44	n.a.	n.a.
Belgium	0.40	13.0	0.09	2.80	−0.15	−4.69	0.08	2.42	0.43	14.0	0.92	29.80	0.85	26.56
Denmark	0.70	21.0	0.07	1.99	−0.18	−5.3	−0.07	−1.99	0.14	4.0	0.91	26.90	0.66	18.80
France	0.07	1.8	0.15	3.04	−0.02	−0.41	0.10	2.03	0.29	6.0	0.51	10.84	0.59	11.99
Germany	1.49	21.0	0.28	3.85	−0.27	−3.72	0.04	0.55	0.11	2.0	1.88	26.85	1.65	22.73
Italy	0.42	7.0	0.28	4.69	0.05	−0.84	0.09	1.51	0.40	7.0	1.10	18.69	1.24	20.81
Netherlands	0.78	17.0	0.04	0.84	−0.16	−3.38	0.01	0.21	0.24	5.0	1.06	22.84	0.91	19.24
Norway	0.13	4.0	0.14	4.05	−0.15	−4.35	−0.07	−2.03	0.24	7.0	0.51	15.05	0.29	8.41
U.K.	0.50	21.0	−0.03	−1.31	−0.15	−6.55	−0.04	−1.75	0.29	12.0	0.76	31.69	0.57	24.89
U.S.A.	0.90	27.0	0.02	0.60	−0.17	−5.28	−0.10	−3.11	0.49	15.0	1.41	42.60	1.14	35.40
Canada	1.5	31.25	n.a.	n.a.	−0.20	−4.17	−0.10	−0.20	0.30	6.0	1.80	37.53	1.50	31.25
Israel	3.5	38.46	n.a.	n.a.	n.a.	n.a.		n.a.			3.50	38.46	3.50	38.46
Japan	2.48	26.38	n.a.	n.a.	n.a.	n.a.	0.10	1.2	0.31	3.3	2.79	29.68	2.89	30.74
Philippines	2.45	42.61	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	2.45	42.61	2.45	42.61
U.S.S.R.	1.33	21.11	n.a.	n.a.	−0.56	−8.89	n.a.	n.a.	0.42	6.67	1.75	27.78	1.19	18.89
Greece	0.65	11.44	n.a.	n.a.	1.45	25.53	0.15	2.6	0.55	9.7	1.20	21.13	2.80	49.30

Sources and Notes to Table III

Sources:

1. Latin American countries, 1950–1962, Correa [11], p. 27, Table 9.
2. Western European countries and U.S., 1950–1962; Denison [12], pp. 298–317, Tables 21-1 to 21-10.
3. Canada, 1950–1962, Walters [44], p. 37, Table 15.
4. Israel, 1950–1965, Gaathon [16], p. 205, Table A-13.
5. Japan, 1952–1967, Chung [9], p. 239, Table 10-1.
6. Philippines, 1948–1961, Lampman [31], pp. 1–2, Table 7.
7. U.S.S.R., 1950–1962, Boretsky [4], p. 12, Table 8.
8. Greece, 1951–1961, Voloudakis [42], p. 48.

Notes:

1. For the Latin American countries, no entry is made for hours and age-sex composition of the labor force due to unavailability of the data.
2. The percentages indicated refer to per cent of growth rates of income shown in Table II.

income in Germany, Canada, U.S., and the U.S.S.R. Note the extremely small contribution of this source in France, Norway and Italy—where it ranges from about 2 to 7 percentage points as can be seen in Column 1 of Table III.

(b) Correa [11] has estimated the contribution of improved health and nutrition to productivity of labor. In his calculation of the contribution of health, he makes adjustments for the reduction in death rates and in work-loss days. The former is of some importance only in Latin American economies and the latter adjustment is very high in the LDC's.[6] The growth rate of the total contribution of improvements in health and nutrition averages over 0.50 in the Latin American countries and around 0.15 for the advanced countries. These estimates suggest that the developed countries have reached, by and large, reasonable levels of health and nutrition that eliminate any further large scale improvements in the quality of their labor on this score.

(c) The growth contribution of reduction in hours worked was calculated by Denison for the U.S. and Western European countries. Data are also available for Canada, the Soviet Union, Greece and Japan, and are shown in Column 3, Table III. In the United States, U.S.S.R. and the advanced Western European countries, the present level of hours of work being approximately optimal, any further reduction does not raise output per man-hour enough to compensate for the reduction in total man-hours; the net effect on output is therefore negative, about -4 to -5 per cent of growth of income. Note the special cases of Japan and U.S.S.R.; the contribution of declining hours is negligible in Japan but negative and substantial in U.S.S.R.

For the LDC's unfortunately, no such evidence is available. It is likely, however, that any decrease in hours of work should make a strong and positive contribution to productivity per man-hour. Consider the case of Greece, where this contribution was positive, twice as large as that of number employed, and about the same as that of capital stock.

(d) The participation rate of labor in different age and sex categories varies considerably in any one economy over time, and from one economy to another. Adjusting for the age-sex composition of the labor force, Denison has computed the contribution of this source to the growth of output of the Western European and U.S. economies. Similar adjustments have also been reported for the Japanese and Canadian labor forces. In all the countries for which data are available this source of adjustment generally contributes very little to the growth of income.

(e) The quantitative estimates of the contribution of education to the growth of income in various economies are shown in Column 5, Table III. This source is responsible for about one-third to one-half of labor's contribution to the growth of output and from 0.11 to over 0.50 percentage points to the growth of income.

[6]The percentage gains from improved health are sizeable in LDC's due to the fact that the initial health conditions, as well as the initial income levels used as a base, are very low.

Denison has argued against any such adjustments for Western European countries on the grounds that they are minor, and do not vary much among these economies. But if we take note of pockets of poverty in the industrialized countries the small contribution of this source stated in the text for these economies is not unreasonable.

The contribution of education to growth of income in Japan, Canada, U.S., Belgium, U.K., U.S.S.R., and Greece is very large. However, the differences in education do not help in explaining the variations in the rates of growth or the levels of income across different countries. The contribution is very large in the slow growing economies, U.S., U.K., and Belgium, while in some fast growing economies, *viz.*, Germany and Japan, it is also low. It is important to note that the effect of education on growth of income is widely diffused, hard to quantify and probably also operates with a very long lag. In developing countries, with the two exceptions of Argentina and Greece, the contribution of education is smaller than in developed countries. The meager contribution of education to growth in Mexico is certainly very surprising and probably inaccurate.

The reason for the small contribution of education in developing countries may be the low rate of return on education compared to that on physical capital. N. Gounden [17] has shown that the rate of return on different types of education in India ranges from 7 per cent for higher education to 17 per cent for primary education. By contrast, the estimates of the rate of return for different types of physical capital varied between 17.2 per cent and 26.1 per cent. This resource disequilibrium is possibly created by the government policy of over-investing in education regardless of demand [6] and by the type of education that is emphasized.[7]

Further evidence on the importance (or potential importance) of education in the growth of underdeveloped countries is provided by the studies of Krueger [30] and Hayami and Ruttan [19]. Kruger's study clearly establishes that, unless the stock of human capital in these countries is improved first, they could not increase their income per capita to the U.S. level even if they were endowed with exactly the same amount of capital and labor as the U.S. Hayami and Ruttan show that human capital (both general and technical education) contributes one-third to narrowing the differential between agricultural productivity in the developing countries and that in the U.S.; general education is the most important type of education. These results are particularly significant in view of the dominance of the agricultural sector in developing economies.

The contribution of total labor input is indicated in Columns 6 and 7 of Table III. The evidence suggests that labor input generally contributes to growth of income more in developing countries than in industrialized economies. In some Western industrialized countries however—U.S., Canada, U.K., and Belgium—the contribution of labor is about 30 to 40 per cent of the growth of

[7]Selowsky [38] has argued that the use of contemporary wage relatives understates the contribution of schooling in "maintaining" the existing quality of education in these countries; since labor force grows very rapidly, the "maintenance" type of investment in education contributes much more than the net improvement of educational quality. Selowsky obtains the following results for several countries:

Country	Contribution of Education		
	Maintenance of Quality	Net Addition to Quality	Total
Chile	50%	36%	86%
Mexico	43%	22%	65%
India	26%	03%	29%
U.S.	33%	52%	85%

income. There is no clear evidence of the association of high labor contribution with high growth rate. In Japan and Israel, labor's contribution is very large while in Germany and the U.S.S.R., also countries with high growth rates, its contribution is very small.

B. Capital Input

Table IV shows the contributions of each type of capital to the growth of income in various countries.[8] Several features of the estimates in Table IV should be noted.

(a) The contribution of total capital stock is very significant in rapidly growing industrialized countries such as Israel, Japan and the U.S.S.R.—between 35 and 52 per cent of their growth rates. The contribution of capital as a per cent of growth of income in developing countries is substantially higher than in the U.S. and Western European countries. Note, however, the surprisingly low figures for Chile and the Philippines. Generally, in the countries with the slowest rates of growth of income (below 3.50)—Belgium, the U.S., Norway and the U.K.—the contribution of capital is small; in France the contribution of both labor and capital is very small.

(b) The contribution of capital in structures and equipment to the growth of income is very high in Israel and Japan (probably in the U.S.S.R. as well!). Among Western countries it has been the greatest in Germany—a country with a substantial rate of growth. The role played by investment is critical in Italy, Israel, and the U.S.S.R.; the development of these countries is imitative, with emphasis on the benefits of imported technology which is often embodied in imported capital. From the statistics shown in this table it is evident that the contribution of capital in structures and equipment, both absolutely and as a per cent of the growth of income, is higher in the developing countries, except for Chile and the Philippines. The variations in the contribution of capital among the countries depend on the existence of complementary factors of production, and the stage of development and diversity of industrial structure of the particular economy. Construction investment (except for communication and transportation investment), being mainly oriented toward the service sectors of the economy, does not contribute as much. In developing countries, the contribution of investment in dwellings is much larger than in Western European countries and the U.S. However, it is also fairly high in Canada, Japan and Israel, a fact which can be partially traced to the enormous temporary shortage of housing in these countries immediately after the war.

[8]Note that we had to combine the contribution of land, capital in structures and equipment, and inventories because of the absence of data, especially for underdeveloped countries. Moreover, with the exception of Israel, capital stock series have not been adjusted for variations in the rate of utilization. An exception is Gaathon [16] who adjusts the capital stock of the Israeli industrial sector, using the power-equipment ratio as a proxy for the rate of utilization. Such an adjustment would have raised the contribution of capital to growth of income. Adjustment for utilization may be more important for developing economies where excess capacity, both in capital and in labor, often persists for long periods of time. We have already noted resource misallocation with respect to education in these countries. Bruton [6] shows that in the Latin American economies the observed productivity increases are due mainly to better resource utilization rather than to any increases in factor productivity (technical change); the opposite situation prevails in the industrialized countries.

TABLE IV

CONTRIBUTION OF CAPITAL TO ECONOMIC GROWTH OF VARIOUS COUNTRIES

Country	Capital in Dwellings		Nonresidential Structural, Land, Equipment, Inventories		International Assets		Total Capital	
	Rate	Per Cent	Rate	Per Cent	Rate	Per Cent	Rate	Per Cent
Argentina	−0.04	−1.21	1.65	41.62	−0.18	−5.51	1.43	44.90
Brazil	0.18	3.24	1.06	30.14	−0.18	−3.24	1.66	30.14
Chile	0.24	5.74	0.25	5.89	−0.17	−4.00	0.32	7.54
Colombia	0.21	4.49	0.95	19.71	−0.12	−2.42	1.04	21.78
Ecuador	0.19	3.99	1.11	23.53	−0.23	−4.78	1.07	22.74
Honduras	0.21	4.60	1.31	20.11	−0.57	−12.59	0.95	21.12
Mexico	0.48	8.13	2.39	30.02	−0.05	−0.80	2.82	47.25
Peru	0.25	4.51	1.49	26.33	−0.34	−6.02	1.40	24.82
Venezuela	0.72	0.29	1.85	23.97	−0.53	−6.90	2.04	26.36
Belgium	0.02	1.0	0.45	15.0	−0.06	−2.0	0.41	14.0
Denmark	0.13	4.0	0.81	24.0	0.02	1.0	0.96	29.0
France	0.02	0.0	0.75	17.0	0.02	0.0	0.79	17.0
Germany	0.14	2.0	1.35	18.0	−0.08	−1.0	1.41	19.0
Italy	0.07	1.0	0.66	12.0	−0.03	−1.0	0.70	12.0
Netherlands	0.06	1.0	0.88	20.0	0.10	2.0	1.04	23.0
Norway	0.04	1.0	0.92	27.0	−0.07	−2.0	0.89	26.0
U.K.	0.04	2.0	0.52	21.0	−0.05	−2.0	0.51	21.0
U.S.	0.25	7.0	0.53	17.0	0.05	1.0	0.83	25.0
Canada	0.30	7.0	1.0	20.0	−0.10	−2.0	1.2	26.0
Greece	0.31	5.46	1.21	21.30	0.03	0.53	1.55	22.9
Israel	0.50	2.20	3.6	33.0	n.a.	n.a.	4.1	35.0
Japan	0.81	8.9	3.7	40.0	0.03	3.0	4.49	52.0
Philippines	n.a.	n.a.	1.01	17.57	n.a.	n.a.	1.01	17.57
U.S.S.R.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	3.15	50.01

Sources: Same as Table III.

Note: In estimating the contribution of capital, three types of capital are distinguished for most countries shown in Table I. Except for the U.S.S.R. the capital stock is always gross of depreciation. For Latin American economies, capital stock in dwellings is estimated using income from dwellings by assuming proportionality between income and capital stock in this sector; contribution of capital in equipment is calculated as a residual. The estimates of the contribution of capital in the U.S. and Western European countries come from Denison.

(c) The contribution of land has generally been negligible in most developed Western countries, though of some importance in developing countries (in Greece, it amounts to about 5 per cent). Although the natural presumption would be that land and natural resources are limiting factors to growth, there is some evidence that the elasticity of substitution between these resources and the neoclassical inputs, labor and capital, is probably either unity or greater than one.

(d) The contribution of international assets is negative in almost all countries. Its magnitude is very large in the developing economies of Latin America as compared to the industrialized countries. In Greece and Japan the contribution of international assets is fairly small in magnitude, but positive.

From the results discussed in Sections A and B, we conclude that, on the whole, the contribution of both capital and labor to the growth of income is much higher in developing than in developed economies, except in the fastest growing countries. The estimates of the contribution of education are probably underestimates in both industrialized and developing nations to the extent that learning on the job is neglected for reasons mentioned. However, on the basis of the figures shown in Table III, no well-defined relationship can be established between differences in the contribution of education and in the rates of growth across countries.

C. Sources of Factor Productivity

Subtracting the contributions of factor inputs from the growth rate of income leaves a residual that has yet to be explained. The purpose of most studies has been to reduce this residual, by identifying economic factors other than the inputs which account for growth of output. The difficulty arises from the ambiguities in measuring the sources and the interdependencies among the identified causes of the growth of factor productivity. Kendrick [27] has shown that total factor productivity for the postwar U.S. economy increased with considerable yearly fluctuations, and that the main factors responsible for its growth were variations in the utilization of tangible capital, growth of the stock of "intangibles" (consisting of education and training, health and mobility of the labor force, and research and development expenditures) and the age of capital. Note that Kendrick, unlike Denison, does not adjust inputs (labor) for quality changes before calculating total factor productivity. His estimated equation for 1948–1966 is:

$$\log X = 0.20 + \underset{(9.04)}{0.53}\ \log X_1 + \underset{(3.02)}{0.81}\ \log X_2 - \underset{(4.49)}{0.43}\ \log X_3$$

where X = total tangible factor productivity; X_1 = ratio of real stock of intangible capital utilized to real tangible factor input; X_2 = utilization rate measured by the ratio of employment to civilian labor force, and X_3 = average age of fixed reproducible capital stock.[9]

Denison, on the other hand, has identified three sets of factors as responsible for the growth of total factor productivity:

1. Improved resource allocation. This is composed of several elements—reduction of agricultural employment, nonagricultural self-employed, and the barriers to international trade.

2. Economies of scale, which Denison has classified into two types: the growth of national markets measured in U.S. prices, and the growth of local markets. Of these the more important is the first, i.e., the difference between the rate of growth of *per capita* consumption of the U.S. and of a given economy.

3. Irregularities in demand pressure, which lead to fluctuation in productivity; this is, in principle, equivalent to adjustments due to fluctuations of the rate of utilization of capital noted earlier.

[9] X_3 dropped from 15.0 years to 10.3 years in the same period. Kendrick does not provide any evidence on serial correlation of the above relation, the presence of which could substantially affect his estimates.

Reliable data for Denison's three components of total factor productivity are not available for many countries. In Table V, therefore, we have constructed a "residual" deducting only the contribution of resource shifts out of agriculture from the factor productivity.[10] This residual contains what Denison calls advances in knowledge, lag in the application of knowledge, improved allocation of resources (other than transfer from agriculture to other industries) and economies of scale. Unfortunately, no data are available on resource reallocation in the economies of Israel, Greece, the Philippines and the U.S.S.R.

The contribution of resource reallocation is generally higher in the U.S. and Western European countries than in the Latin American countries, except for Argentina and Honduras, where the entire residual is attributed to resource reallocation alone. In the developing countries the smaller contribution of this factor may be due to their surplus supply of labor and the inadequate labor-absorption capacity of the industrial sector.

The values of the residual as a percentage of growth of income are much smaller in Latin American countries than in advanced countries. This suggests that in developing countries growth is much more dependent on the supply of inputs than in the advanced countries. Note, however, that the residual is substantial in Chile, Greece, Ecuador and the Philippines but trivial in Argentina, Ecuador and Mexico. Among the industrialized economies, the share of the residual is very large—over 50 per cent of growth of income in the case of France and Italy, and over 40 per cent of income growth in the others, with the exceptions of Denmark, U.S., Canada, the U.S.S.R., Japan and Israel.[11] Thus, no clear correlation exists between the differences in the rates of growth of the residual and growth rates of income across countries. It is important to note also that productivity growth cannot be completely independent of the growth of input. Resources, especially capital formation, are needed (probably for design changes) to exploit the potential economies of scale for the adaptation and reallocation of resources and for the advancement of knowledge.

IV. Retardation, Variations, and Sectoral Distribution of the Growth Rates

The growth rates shown in Table II are averages for the period 1950–1962 and conceal the acceleration or retardation, yearly variations, and the industrial distribution of factor productivity. These dynamic features of the growth phenomenon are most interesting but very little intensive research has, so far,

[10]Denison's figures show that the contraction of agriculture, which is the most important type of resource re-allocation, constitutes 12–17 per cent of the growth of income in Denmark, France, Germany, Norway and Italy, 6–7 per cent in the Netherlands, U.S. and Belgium, and is very low for England, about 3 per cent. The adjustment for economies of scale is fairly uniform across countries—about 9 to 12 per cent of the growth of income. The ranking of countries according to the size of the unexplained residuals depends on the nature of the adjustment for economies of scale. But it has been argued [35] that the adjustment for the economies of scale is circular with little explanatory value, since it explains the differences in countries' output growth as a function of itself. Therefore, we shall refrain from attempting any further decomposition of the residual in Table V.

[11]The impressive growth of factor productivity in France has been attributed to the substantial success of French economic planning in transforming the environment entrepreneural activities in the country.

TABLE V

CONTRIBUTION OF INPUTS, RESOURCE ALLOCATION, AND "RESIDUAL" TO GROWTH OF INCOME IN VARIOUS COUNTRIES

Country	Total Factor Inputs		Reallocation of Resources		Residual	
	Rate	Per Cent	Rate	Per Cent	Rate	Per Cent
Argentina	3.01	94.23	0.20	6.20	0.00	0.00
Brazil	4.10	74.61	0.39	7.15	1.00	18.00
Chile	1.37	32.48	0.11	2.54	2.73	65.15
Colombia	3.39	70.87	0.33	6.90	1.06	22.11
Ecuador	2.54	53.97	−0.35	−7.37	2.52	53.37
Honduras	3.12	69.50	1.38	30.55	0.00	0.00
Mexico	5.23	87.70	0.44	7.37	0.20	4.84
Peru	2.80	49.82	0.36	6.33	2.60	46.27
Venezuela	4.63	59.80	0.56	7.37	2.55	32.93
Belgium	1.33	43.80	0.20	7.00	1.67	40.20
Denmark	1.87	55.99	0.41	12.00	1.23	32.01
France	1.30	27.84	0.65	14.00	2.97	53.16
Germany	3.29	45.85	0.77	10.00	3.20	44.15
Italy	1.80	30.00	1.04	17.00	3.12	52.31
Netherlands	2.10	45.84	0.21	5.00	2.42	40.16
Norway	1.40	41.05	0.54	16.00	1.51	42.95
U.K.	1.27	52.69	0.06	3.00	0.96	44.31
U.S.	2.24	67.60	0.25	7.00	0.73	25.40
Canada	3.00	66.96	0.60	13.30	1.20	26.79
Greece	1.07	18.84	n.a.	n.a.	n.a.	n.a.
Israel	7.60	69.09	n.a.	n.a.	3.4	30.90
Japan	6.98	74.10	0.91	9.00	1.53	16.24
Philippines	3.25	56.52	n.a.	n.a.	2.50	43.48
U.S.S.R.	4.48	71.11	n.a.	n.a.	1.82	28.57

Sources: Same as Table III.

[a]Hours worked and age-sex composition of labor are not included in measurement of inputs.

been reported. I shall briefly address two main issues in this section: (a) the marked retardation or stagnation of the growth rates in most countries in the second subperiod, i.e., 1955–1962; and (b) the variability of the rates of growth over time and across industries.

A. Retardation of the Growth Rates

In Table VI, the growth rates of income, contribution of employment, capital stock and factor productivity in several countries for two subperiods are indicated. Note that the time periods are not the same for all the countries. Several features of the statistics in the table are noteworthy.

(i) In most countries, excluding France, Japan, Denmark and Greece, the growth rates of national income declined during the second period. This retarda-

TABLE VI

ANALYSIS OF THE GROWTH RATES OF NATIONAL INCOME IN TWO PERIDOS

Country	National Income		Employment		Capital Stock		Total Factor Productivity	
	I	II	I	II	I	II	I	II
Belgium	3.25	3.18	0.51	0.33	0.43	0.40	1.92	2.12
Canada	5.20	4.50	1.30	1.70	1.80	0.80	2.10	2.10
Denmark	1.58	4.92	0.35	0.95	0.91	0.99	0.20	3.25
France	4.77	5.03	0.08	0.09	0.71	0.84	3.60	3.75
Germany	9.93	5.39	2.01	1.13	1.20	1.57	6.74	2.88
Greece	5.68	6.52	0.65	0.69	1.63	2.25	0.86	2.57
Israel	13.30	9.60	5.10	2.90	4.10	3.50	4.10	3.20
Italy	6.30	5.71	1.35	0.20	0.57	0.80	4.38	4.23
Japan	8.86	10.06	2.42	2.38	3.48	5.21	2.64	1.87
Netherlands	6.00	3.86	0.81	0.76	1.18	0.94	3.67	2.21
Norway	3.69	3.27	0.14	0.13	1.14	0.72	2.14	2.58
U.K.	2.32	2.27	0.69	0.37	0.10	0.80	1.27	1.12
U.S.	4.23	2.67	1.13	0.73	0.98	0.73	1.93	0.97
U.S.S.R.	7.10	5.30	0.84	0.42	2.50	2.80	3.70	2.00

Sources:

1. U.S. and Western European countries, Denison [12], pp. 298–317, Tables 21-1–21-10.
2. Canada, Walters [44].
3. Japan, Chung [9].
4. Israel, Gaathon [16].
5. U.S.S.R., Cohn [10].
6. Greece, Voloudakis [42].

Note: The subperiods I and II cover periods 1950–1955 and 1955–1962 for U.S., Canada and the Western European countries For other countries the subperiods are: Japan, 1952–1960 and 1960–1967; Israel and U.S.S.R., 1950–1958 and 1958–1964; and Greece, 1951–1961 and 1961–1966.

tion is particularly pronounced in Israel, Germany, Netherlands and the U.S.S.R.

(ii) In most Western European countries, both employment and capital were significantly less important sources of growth in the second period. Hours worked, and age–sex composition of labor contributed negatively to growth in advanced economies, especially in the period 1955–1962. The contribution of education was very high in the U.S., the U.K. and Belgium (about 12–15 per cent), but much smaller in other countries in the second period. Land and international assets were often minor participants in the growth process in both periods; the dynamic role of foreign trade as a vehicle for transfer of technical know-how should, however, be underscored. Factor productivity was the single most important source of growth common to all the countries in both subperiods. Its contribution generally ranged from 50 to 80 per cent of the growth rate in most countries except for the U.S. and Canada.

Aside from these observations, the important question that arises is that of the reasons for the existence and pervasiveness of growth retardation. The main factors that might have been responsible for this development can be that: (a) the labor supply became inelastic in the second period and (b) the rate of growth of total factor productivity declined considerably. The evidence is provided in Table VII.

(a) The major factor which permitted the remarkable growth in the early 1950's was the availability of a large supply of labor in many economies. At that time the growth experience of most countries followed the Lewis model of

TABLE VII

THE DIFFERENCES IN GROWTH RATES OF NATIONAL INCOME, EMPLOYMENT, TOTAL CAPITAL STOCK, CAPITAL STOCK IN STRUCTURES AND EQUIPMENT AND TOTAL FACTOR PRODUCTIVITY BETWEEN PERIODS I AND II

Country	National Income	Employment	Capital Stock	Capital Stock in Structures and Equipment	Total Factor Productivity
Belgium	−1.56	−0.40	−0.25	−0.19	−0.96
Canada	−0.70	0.40	−1.00	−0.20	0.00
Denmark	3.34	−0.60	0.08	0.02	3.05
France	0.26	−0.01	0.13	0.07	0.15
Germany	−4.54	−0.88	0.37	0.29	−3.86
Greece	0.84	0.04	0.62	−0.49	1.71
Israel	−3.70	−2.20	−0.60	0.50	−0.90
Italy	−0.59	−1.15	0.23	0.12	−0.15
Japan	1.20	−0.04	1.73	0.94	−0.77
Netherlands	−2.14	−0.05	−0.24	0.24	−1.46
Norway	−0.42	−0.01	−0.42	−0.25	−0.44
U.K.	−0.05	−0.32	0.70	0.08	−0.15
U.S.	−1.56	−0.40	−0.25	−0.19	−0.96
U.S.S.R.	−1.80	−0.42	0.30	n.a.	−1.70

Sources and subperiods are the same as Table VI.

"Growth With Unlimited Supply of Labor," [33], [29]. The increase in labor in various economies had different sources: natural increase (Netherlands, the U.S.S.R.), transfer from agriculture (Germany, France, Japan and Italy), immigration (Israel, Germany), and higher participation rates (Canada, the U.S.S.R.). Moreover, the skill level of the labor forces in different countries had been retained intact in spite of the war-time destruction.

This picture changed dramatically during the second period. In most economies, supply of labor became inelastic due to demographic factors, exhaustion of reservoirs of under-employment, stoppage of the flow of immigration, etc. Consequently, the contribution of employment declined, often dramatically, during the second period as witnessed in Germany, Italy, Israel and the U.S.S.R. In countries where the supply of workers remained, or became, fairly elastic—Japan, Denmark and Greece—the growth rate of national income increased, often substantially, as can be seen from Table VII.

(b) The decline in factor productivity, though necessarily affected by factors peculiar to a given economy, can be said to have been due to the inability of the economies to reallocate resources out of agriculture, and to the possible exhaustion of economies of scale.

An interesting thesis proposed by Kaldor [24] is that while an elastic aggregate supply of labor is necessary for a rapid rate of growth, the distribution of the labor supply among different industries is also critical. Kaldor has argued that the shift of resources, especially labor, from slow-growing to rapid-growing sectors raises the over-all growth rates of various economies. Growth in the industrial sector, mainly manufacturing, largely determines the rate of growth of the entire economy. However, the converse relationship does not hold. Kaldor identified two important characteristics of the industrial sector and especially manufacturing. It is generally subject to economies of scale, and the rate of growth of productivity is positively related to growth of manufacturing output. Growth of the investment/output ratio may also play some role in explaining the growth of productivity, but it is the growth of output in the industrial sector which is critical.

In most countries, the factor that constrains the growth of the industrial sector is unavailability of labor, and the major source of labor in most countries is reduction of employment in other sectors, especially agriculture. Thus, reallocation of resources, mainly labor, becomes critical for the continuation of the growth process. On the basis of cross-sectional data for twelve Western countries, Kaldor maintains that:

$$(dy/y) = \alpha_0 + \alpha_1 (dx/x); \alpha_0 > 0; \quad 0 < \alpha_1 < 1$$

where dy/y and dx/x are the rates of growth of aggregate national income and of income originating in manufacturing. The necessary condition for the argument stated above to be valid is that the coefficient of (dx/x) be positive but *less* than unity. If it is greater than or equal to one, the causation runs from y to x. Furthermore, Kaldor states the relation—

$$\frac{dA}{A} = \beta_0 + \beta_1 \left(\frac{dx}{x}\right); \qquad \beta_0 > 0 \quad \text{and} \quad 0 < \beta_1 < 1$$

where dA/A is growth of productivity.

It is interesting to note that Kendrick, in his recent study [27], also finds a strong positive and significant relationship between changes in the growth of factor productivity and the growth of output in the U.S. industrial sector. He reports the following relation for the period 1948–1966:

$$\frac{dA}{A} = 3.179 + \underset{(4.475)}{0.304}\left(\frac{dx}{x}\right) - \underset{(2.810)}{0.035}\ U; \qquad R^2 = 0.773$$

where dA/A and dx/x are annual percentage changes in total factor productivity and in output; U is the percentage of employees of the industries belonging to labor unions in the base year 1958.

Further evidence is provided from the recent retardation of the Soviet economy recorded by Cohn [10], Kaplan [25], Bergson [2], Thornton [40] and Weitzman [45]. Their work suggests that inability to reduce the high proportion of its labor force in agriculture, and slow growth of its industrial sector were responsible for the retardation of the over-all growth rates of U.S.S.R. since 1958. The Japanese economy, on the other hand, has been quite successful in shifting resources out of agriculture which, in concert with other forces, has been responsible for its remarkable growth, particularly in the industrial sector.

It is hard to judge precisely whether the retardations noted above are transient or long run. It is probable that the economies are merely returning to their normal trend growth, if the high rates of the early 1950's were largely due to transient forces—postwar reconstruction, imbalance in the capital structure of the economies, lagged economies catching up with others, etc.

B. Sectoral Distribution of Productivity Growth Rates

The growth of an economy is primarily an average of the rate of growth of different sectors and industries. Industries rarely grow at uniform rates and the growth process is generally unbalanced. Kendrick [27] has calculated the postwar growth rates of total factor productivity for different sectors and industries of the U.S. economy. His results indicate the following.

(i) There were considerable variations in the rate of growth of output and factor productivity among different sectors; their time profiles varied depending on the total length and phase of the business cycles; the dispersion of the growth rates was greater for the subperiods and the lower level of industry aggregation than for longer periods and the sectoral level.

(ii) Technical progress was more widely diffused during the postwar period than previously; and the rate of growth of factor productivity was positively correlated with that of output, as noted earlier.

(iii) The higher the rate of growth of the economy the greater the dispersion of technological progress among industries; though the rates of growth of output are quite different between industries within an economy, there are even larger differences among the rates of technological progress for the same industries across the two economies. However, the industries with high rates of technological progress in one country tend to correspond to those with high rates in Japan [20], [43].

(iv) Some economies do exhibit non-optimal allocation of capital and labor among sectors and among establishments of different sizes; transformation of the industrial structure by changing the industry output-mix does evolve over time and it must to avoid stagnation in the long-run growth of the economy. The distributions of the growth rates and per capita income (or percentage share of population in agriculture) across economies at different states of development are shown to be an inverted V or "bell" shaped. This suggests that the economies grow rapidly first until they reach a critical level of per capita income and thereafter the rates decline with further stages of economic development.[12]

The interindustry shifts of resources and the changing hierarchy of technological progress from one industry to another constitute the dynamic forces which determine the acceleration or retardation of the over-all growth rate. Considerably greater research effort is required for a (more) thorough understanding of the dynamic forces operating in different economies and to specify the exact linkages between the evolution of industrial structure and the aggregate growth of the economy.

V. Concluding Remarks

The studies mentioned here represent attempts to identify the causes of growth in different economies. Some of the estimates are tentative and judgmental. The growth accountancy approach is a step toward providing a reconciliation of the economic balance sheets for growth in many countries. Unfortunately, the data requirements for implementing this scheme are very severe, and for many countries, even basic summary statistics such as labor productivity indices are simply not yet available. Often the data used in these studies are suspect and not sufficiently comparable to allow precise comparison of economic performance of various countries. Further, the unresolved conceptual problem is that the sources of growth that have been identified so far are often not independent of each other, creating problems of identification.

However, the discussion in this paper suggests that:

(a) Contribution of inputs is generally high in both developing countries and fastest growing advanced countries. Contribution of factor productivity is small in developing economies as compared to its critical importance in industrialized countries.

(b) Elasticity of labor supply plays an important role in the growth of advanced economies. It is increased either by a shift of labor away from slow-growing sectors to more rapid-growing ones (especially manufacturing), or by an improvement in the quality of the labor force, mainly through education. Capital stock plays an important role in LDC's and in rapidly growing economies, but its contribution to growth is relatively low in the advanced economies of the West. Reliance of the "latecomers" on capital stock is partly due to the fact that capital serves as a carrier of technical change in these economies.

(c) There are substantial differences among growth rates of different industries in different economies; countries with high rates of growth experience

[12]This statement is based on the results of the yet unpublished research of Professor Branko Horvat and his associates. I am grateful to Professor Horvat for making some of his results available to me.

wider dispersion of sectoral growth rates. Productivity growth in agriculture and manufacturing has been very high, especially in rapidly-growing industrialized economies (except for agriculture in the U.S.S.R.). Most of the rise in agricultural productivity has led to a release of labor to other sectors.

Three problems that deserve further consideration need to be noted.

1. Measures of GNP or national income (or their per capita counterparts) exclusively relied upon by economists are not appropriate for welfare measurements. They exclude nonmarket activities, and lack adequate treatment of consumer durables and adjustment for new products.[13] Moreover, externalities in production and consumption, such as urbanization congestion and pollution are excluded. Omission of leisure as part of income substantially understates economic welfare. The conceptual problem of defining and measuring the output of the government and service sectors still remains to be adequately dealt with. We need to know the contribution of government to growth by the type and quality of service it renders, especially in developing economies, where governments play a very strategic role.

2. The use of factor shares as weights in calculating the contribution of various inputs to the growth of output is problematic, in view of the growing importance of externalities forcing private and social costs to diverge and the growth of public services in every economy. Further, in the case of disequilibrium in the economy, market shares are biased indicators of marginal product of the inputs. There is some evidence on this issue: Thurow [41] has shown that, for the U.S. economy, there is a substantial gap between the marginal products of labor and capital and their returns. His calculations, based on the familiar set of time-series aggregate data, suggest that labor remuneration is considerably below its marginal product, while the opposite is true for capital. A similar point (but with opposite direction than Thurow) is made by Bruno [5] in his analysis of the Israeli economy. If such evidence existed for other countries, we would have to reformulate the concept of growth accountancy in a more dynamic framework.

3. The interactions among the sources of factor productivity deserve more attention. Labor supply and technical change are often considered exogenous but, as Easterlin [15] has argued, the fertility rate is affected by economic activity. Moreover, education may affect not only the skill characteristics, but also the participation rate of the labor force, and even the fertility rate. Similarly, adoption of new techniques may depend on the rate of growth of output and of capital stock; new innovations are associated with an expanding economy and a higher level of education of the labor force. Consideration of these interactions requires a dynamic feedback model which emphasizes the linkage among inputs and their quality characteristics. In such a system, technical change must be treated as endogenous to the economic system.

4. More attention needs to be devoted to the sectoral imbalances. The structure of output and preferences change in the course of economic develop-

[13]The income figures are subject to continuous revisions which may invalidate some of the conclusions about the contribution of factors to growth of income and about the magnitude and sources of total factor productivity. The Canadian experience provides a good example, see [44].

ment; resources are continually shifted from one sector to another; identification of the leading growth sectors and their disequilibrating effects on the rest of the economy need to be explored. Both the production function and the growth accountancy approaches conceal, through aggregation and generality, the basic drama of birth and disappearance of new products, technologies, industries and the accompanying changes in spatial and occupational distribution of the population. In international growth comparisons, we need to know more about the process of diffusion of technology from one country to another, and the role of international trade as a source of demand and as a vehicle of technical change.

This list, though by no means exhaustive, provides a formidable agenda for further research, most of which cannot be accomplished immediately. Not only are new and better data needed, but also models must be developed and estimated which combine meaningfully the socio-economic factors.

References

[1] Aukrust, O., "Factors of Economic Development—A Review of Recent Research," *Prod. Measurement Review*, Feb. 1965, 40, pp. 6–22.

[2] Bergson, A., *Planning and Productivity Under Soviet Socialism*, Columbia University Press, New York, 1968.

[2a] Bergson, A., "Comparative Productivity and Efficiency in the Soviet Union and the United States," in Alexander Eckstein, ed., *Comparison of Economic Systems*, University of California Press (Berkeley, 1971).

[3] Bowles, S., "Sources of Growth in the Greek Economy, 1951–1961," *Cambridge Center for International Affairs*, mimeo., 1966.

[4] Boretsky, M., "Comparative Progress in Technology, Productivity, and Economic Efficiency, USSR vs. USA," *in New Directions in the Soviet Economy*, U.S. Congress, Joint Economic Committee, Washington, 1966, pp. 133–256.

[5] Bruno, M., "Estimation of Factor Contribution to Growth Under Structural Disequilibrium," *International Economic Review*, 9, Feb. 1968, pp. 49–62.

[6] Bruton, H., "Productivity Growth in Latin America," *American Economic Review*, Dec. 1967, pp. 1099–1116.

[7] Christensen, L., and Jorgenson, D., "The Measurement of U.S. Real Capital Input, 1929–1967," *Review of Income and Wealth*, Dec. 1969, 15 (4), pp. 293–320.

[8] ———, "U.S. Real Product and Real Factor Input, 1929–1967," *Review of Income and Wealth*, March 1970, 16 (1), pp. 19–50.

[9] Chung, W., "A Study of Economic Growth in Postwar Japan for the Period 1952–1967. An Application of Total Productivity Analysis," mimeo., Denison University, Nov. 1970.

[10] Cohn, S., "Soviet Growth Retardation: Trends in Resource Availability and Efficiency," in *New Directions in the Soviet Economy*, U.S. Congress, Joint Economic Committee, Washington, 1966, pp. 99–132.

[11] Correa, H., "Sources of Economic Growth in Latin America," *Southern Economic Journal*, Vol. 37, No. 1, July 1970, pp. 17–31.

[12] Denison, E., *Why Growth Rates Differ: Postwar Experience in Nine Western Countries*. The Brookings Institution, Washington, 1967.

[13] Denison, E., "Some Major Issues in Productivity Analysis: An Examination of Estimates by Jorgenson and Griliches," *Survey of Current Business*, May 1969, Part II, 49 (5), pp. 1–28.

[14] ———, "Production Function Implicit in *Why Growth Rates Differ*," mimeo., Brookings Institution, May 1969.

[15] Easterlin, R., *Population, Labor Force, and Long Swings in Economic Growth, The American Experience*, NBER, Columbia University Press, New York, 1968.

[16] Gaathan, S., *Economic Productivity in Israel*, Praeger, New York, 1971.

[17] Gounden, A., "Investment in Education in India," *Journal of Human Resources*, Vol. 2, No. 3, Summer 1967, pp. 347–358.

[18] Griliches, Z., "Production Functions in Manufacturing: Some Preliminary Results," in M. Brown ed., *The Theory and Empirical Analysis of Production*. NBER, New York 1967, pp. 275–322.

[19] Hayami, Y. and V. Ruttan, "Agricultural Productivity Differences Among Countries," *American Economic Review*, Vol. 60 (5), Dec. 1970, pp. 895–911.
[20] Ichimura, S., "Factors for Rapid Economic Growth: A Social Accounting Approach," in L. Klein and K. Ohkawa (eds.), *Economic Growth, The Japanese Experience Since the Meiji Era*, Irwin, 1968, pp. 245–277.
[21] International Labor Organization, *Measuring Labor Productivity*, Geneva, 1969.
[22] Jorgenson, D. and Z. Griliches, "The Explanation of Productivity Change," *Review Econ. Stud.*, July 1967, 34 (3), 99, pp. 249–84.
[23] ———, "The Sources of Economic Growth: A Reply to Edward F. Denison, " mimeo., Harvard Institute of Economic Research, 1970.
[24] Kaldor, N., *Strategic Factors in Economic Development*, New York State School of Industrial and Labor Relations, Cornell University, Ithaca, New York, 1967.
[25] Kaplan, N., "Retardation in Soviet Growth," *Review of Econ. Stat.* Aug. 1968, pp. 293–303.
[26] Kendrick, J., *Productivity Trends in the United States*, NBER, Princeton University Press, Princeton, 1961.
[27] Kendrick, J., *Postwar Productivity Trends in the United States*, NBER, mimeo., 1970.
[28] ——— and R. Sato, "Factor Prices, Productivity and Economic Growth," *American Economic Review*, Dec. 1963, 53 (5), pp. 974–1003.
[29] Kindleberger, C., *Europe's Postwar Growth: The Role of Labor Supply*, Harvard University Press, Cambridge, 1967.
[30] Krueger, A., "Factor Endowments and Per Capita Income Differences Among Countries," *Economic Journal*, Sept. 1968, 78, No. 311, pp. 641–659.
[31] Lampman, R., "The Sources of Post-War Growth in the Philippines," *The Philippines Economic Journal*, Vol. 6, No. 2, pp. 170–187.
[32] Levhari, E., Kleiman, E., and N. Halevi, "The Relationship Between Two Measures of Total Productivity," *Review Econ. Stat.*, Aug. 1966, 48 (3), pp. 345–347.
[33] Lewis, A., "Development with Unlimited Supplies of Labor," *The Manchester School*, 22, May 1954, pp. 139–191.
[34] Maddison, A., *Economic Growth in the West*, The Twentieth Century Fund, New York, 1964.
[35] Matthews, R., "Why Growth Rates Differ?" *Economic Journal*, June 1969, pp. 261–268.
[35a] Nadiri, M. I., "Some Approaches to the Theory and Measurement of Total Factor Productivity: A Survey." *Journal of Economic Literature*, Vol. 8, No. 4 (Dec. 1970), pp. 1137–1177.
[36] Paige, D., Blackaby, F., and S. Freund, "Economic Growth: The Last Hundred Years," *National Institute Economic Review*, No. 16, July 1961, pp. 24–49.
[37] Psacharopoulos, G., *The Anatomy of a Rate of Growth: The Case of Hawaii*, 1950–1960, Economic Research Center, University of Hawaii, March 1969.
[38] Selowsky, M., "On the Measurement of Education's Contribution to Growth," *Quarterly Journal of Economics*, Aug. 1969, pp. 449–463.
[39] Solow, R., "Technical Change and the Aggregate Production Function," *Review Econ. Stat.*, Aug. 1957, 39 (3), pp. 312–20.
[40] Thornton, J., "Value Added and Factor Productivity in Soviet Industry," *The American Economic Review*, 60 (5), Dec. 1970, pp. 863–71.
[41] Thurow, L., "Disequilibrium and the Marginal Productivity of Capital and Labor," *Review Econ. Stat.*, Feb. 1968, 59 (1), pp. 23–31.
[42] Voloudakis, E., "Major Sources of the Postwar Growth of the Greek Economy," mimeo., Athens, 1970.
[43] Watanabe, T., "Industrialization, Technological Progress and Dual Structure," in L. Klein and K. Ohkawa (eds.), *Economic Growth: The Japanese Experience Since the Meiji Era*, Irwin 1968, pp. 110–134.
[44] Walters, D., "Canadian Growth Revisted, 1953–1967," Staff Study No. 28, for the *Seventh Annual Review*, Economic Council of Canada.
[45] Weitzman, M., "Soviet Economic Growth and Capital-Labor Substitution," *American Economic Review*, Sept. 1970, pp. 676–92.