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11 Economic Growth, 1947–73; An International Comparison

Laurits R. Christensen, Dianne Cummings, and Dale W. Jorgenson

11.1 Introduction

11.1.1 Introduction

The purpose of this paper is to provide an international comparison of postwar patterns of aggregate economic growth for the United States and eight of its major trading partners—Canada, France, Germany, Italy, Japan, Korea, the Netherlands, and the United Kingdom. Our study covers the period 1947–73 for the United States and as much of this period as is feasible for each of the eight remaining countries. We compare growth in real product, real factor input, and total factor productivity for all nine countries for the period 1960–73. For all countries except Korea we compare growth during this period with growth beginning at earlier times and extending through 1960.

A complete analysis of aggregate economic growth involves the growth of real product and its sources—growth in real factor input and growth in total factor productivity. Growth in real factor input can be further divided between growth in real capital input and in real labor input. Growth in capital input involves growth in capital stock as a component of wealth through saving and capital formation. Analysis of growth in capital requires a complete accounting system, consisting of a production account, an income and expenditure account, an accumulation account, and a wealth account—all in current and constant prices.

Christensen and Jorgenson (1969, 1970, 1973*a*, 1973*b*) have developed a complete accounting system that is well adapted to the analysis of aggregate economic growth and have implemented this system for the United States for the period 1929–69. In this paper we limit considera-

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tion to the production account, containing data on output and input in current and constant prices. We have extended the production account for the United States through 1973 and have implemented this account for each of the eight remaining countries. Our data on output and input are compiled in a form suitable for integration into a complete system of accounts for each country.

We first provide a brief review of previous international comparisons of patterns of aggregate economic growth that are similar in scope to this study. We discuss the selection of countries to be included and the selection of an appropriate time period for our international comparisons. In section 11.2 we present our methodology for measuring real product, real factor input, and total factor productivity. This methodology is based on the economic theory of production, beginning with a production function giving output as a function of capital input, labor input, and time. We derive index numbers of real product, real capital input, real labor input, and total factor productivity from this theory.

In section 11.3 we outline the empirical implementation of our index numbers of real product, real factor input, and total factor productivity for the nine countries included in our study. In section 11.4 we present an international comparison of patterns of economic growth for all nine countries. Our principal finding is that differences in growth rates of real product for the period 1960–73 are associated with differences in growth rates of real factor input. An intertemporal comparison of growth rates during this period with growth rates during earlier periods ending in 1960 strongly reinforces this conclusion. Increases and decreases in growth rates of real product are associated with increases and decreases in growth rates of real factor input. We present a more detailed summary of our conclusions in section 11.5.

11.1.2 Alternative Methodologies

International comparisons of patterns of economic growth are no longer uncommon, but the number of studies providing real product and real factor input in both current and constant prices on an economy-wide basis is not large. We can set the stage for our detailed discussion of methodology by briefly summarizing the approaches that have been used in previous studies. In table 11.1 we present a tabular comparison among the most important of these studies for developed countries.[1]

1. Detailed surveys of the literature on total factor productivity have been given by Nadiri (1970) and by Kennedy and Thirlwall (1972). Nadiri (1972) has presented an international survey of estimates of growth of total factor productivity. Balassa and Bertrand (1970) have compared sources of economic growth in Eastern and Western Europe. Correa (1970) has compared sources of economic growth for Latin American countries. Patterns of economic growth have been studied from a more comprehensive perspective by Kuznets (1971) and by Chenery and Syrquin (1975).

Table 11.1 **International Comparisons of Growth in Total Factor Productivity**

	Authors					
	Tinbergen (1942)	Domar (1964)	Denison (1967)	Barger (1969)	Kuznets (1971)	Bergson (1974)
			Belgium			
		Canada			Canada	
			Denmark	Denmark		
	France		France	France	France	France
	Germany	Germany	Germany	Germany		Germany
			Italy	Italy		Italy
		Japan				Japan
			Netherlands	Netherlands		
			Norway	Norway	Norway	
				Sweden		
						U.S.S.R.
	U.K.	U.K.	U.K.	U.K.	U.K.	U.K.
	U.S.A.	U.S.A.	U.S.A.	U.S.A.	U.S.A.	U.S.A.
Time period	1870–1914	1948–60	1950–62	1950–64	1855–1966	1955–70

The concept of total factor productivity, defined as the ratio between real product and real factor input, was introduced in a notable but neglected article by Tinbergen (1942).[2] Among the many remarkable features of Tinbergen's study is an international comparison of growth in real product, real factor input, and total factor productivity for France, Germany, the U.K., and the U.S.A. for the period 1870–1914.

The concept of total factor productivity was developed independent of Tinbergen's work by Stigler (1947). The point of departure for this development was the measurement of real factor input by weighting real capital input and real labor input by their marginal products. Important contributions to the measurement of total factor productivity were made during the 1950s by Mills (1952), Schmookler (1952), Knowles (1954, 1960), Valavanis-Vail (1955), Abramovitz (1956), Kendrick (1956), Solow (1957), and Fabricant (1959). The initial approach to total factor productivity measurement was brought to fruition by the epochal work of Kendrick (1961). The first international comparison of growth in total factor productivity, subsequent to Tinbergen's pioneering effort, was published by Domar (1964) and five collaborators, employing the methodology of Kendrick's study for the United States. Domar's study included Canada, Germany, Japan, the U.K., and the U.S.A. and covered the period 1948–60. A notable feature of the study was the development of separate estimates for as many as eleven sectors within each of the five countries.

Griliches (1960) and Denison (1962) extended the original framework for the measurement of total factor productivity by applying the principle of weighting inputs by their marginal products to components of real labor input. Griliches and Jorgenson (1966, 1967) followed up this new departure in methodology by applying the same principle to components of real capital input. Christensen and Jorgenson (1969) developed a detailed methodology for weighting components of real capital input disaggregated by class of asset and by legal form of organization. This methodology incorporates data on the taxation of income from capital at both corporate and personal levels and data on rates of return and depreciation by asset class and legal form of organization.

Denison's study of U.S. economic growth (1962) was followed in 1967 by the appearance of his volume, *Why Growth Rates Differ*, comparing U.S. economic growth for the period 1950–62 with growth in eight European countries. Although Denison's international comparisons of growth in real product, real factor input, and total factor productivity, which he denotes output per unit of input, were limited to the nine countries listed in table 11.1, the same methodology has been

2. The first English-language reference to Tinbergen's article that has come to out attention is by Valavanis-Vail (1955).

employed by Walters (1968, 1970) in two studies for Canada and by Denison and Chung (1976) in a study for Japan.[3] Denison (1974) has also extended the time period of his estimates for the United States, based on the methodology of *Why Growth Rates Differ*, to include the years 1929–69.

Concluding our brief survey of international comparisons, we can draw attention to Barger's (1969) comparison of growth for nine countries—Denison's list with Belgium being replaced by Sweden—for the period 1950–64. This study incorporates embodied as well as disembodied sources of economic growth. Kuznets (1971) has provided a comparison of Denison's results for the postwar period with his own analysis of long-term growth trends for Canada, France, Norway, the U.K. and the U.S.A.[4] Finally, as part of a research program on Soviet economic growth, Bergson (1974) has compared the growth of Soviet real product, real factor input, and total factor productivity with that of six Western countries for the period 1955–70.

11.1.3 Selection of a Methodology

In selecting an appropriate methodology for our study, Denison's approach in *Why Growth Rates Differ*, his subsequent studies of Japanese and U.S. economic growth, and the studies of Canada by Walters deserve serious consideration. For present purposes Denison's approach can be separated into three interrelated components. First, for each country Denison has measured real product, real factor input, and total factor productivity. Second, for each country Denison has analyzed the growth in output per unit of input into ten separate sources, including advances of knowledge, improved allocation of resources, balance of the capital stock, economies of scale, and a residual factor. Third, Denison has provided a comparison of productivity levels for all nine countries for the year 1960.

Our study is limited to the development of a production account within a complete accounting system, so that we focus attention on Denison's measurement of real product, real factor input, and total factor productivity. Jorgenson and Griliches (1972*a*) have compared Denison's results for the U.S.A. with those of Christensen and Jorgenson (1970) for the period covered by *Why Growth Rates Differ*, 1950–62.[5]

3. Denison's methodology is also employed in a study for Japan by Kanamori (1972).

4. Hopefully this analysis will soon be complemented by a study of long-term growth trends for France, Germany, Italy, Japan, Sweden, the U.K., and the U.S.A. by the Social Science Research Council group under the overall direction of Abramovitz and Kuznets.

5. Earlier, Denison (1969) had compared his results with estimates by Jorgenson and Griliches (1967). For Denison's reply to Jorgenson and Griliches (1972*a*), see Denison (1972).

They conclude that the growth of real factor input accounts for a much larger proportion of growth in real product in the Christensen-Jorgenson study than in Denison's study, and that the differences in results can be traced to differences in the methodology for measuring real capital input.

Jorgenson and Griliches (1972*a*, *b*) have compared the methodology of Christensen and Jorgenson for measuring real capital input with that employed by Denison in *Why Growth Rates Differ*. They show that, by contrast with the approach of Christensen and Jorgenson, Denison's methodology fails to incorporate differences in the marginal products of capital inputs in a satisfactory way.[6] In particular, Denison fails to incorporate the effects of taxation of income from capital at both corporate and personal levels, to measure differences in rates of return and depreciation by asset class and legal form of organization, and to account properly for the impact of differences in the rate of change of the prices of different assets on rates of return. Finally, he fails to treat depreciation and replacement of capital stock in an internally consistent way.

Denison's methodology for *Why Growth Rates Differ* has been subjected to searching scrutiny from a completely different point of view by Maddison (1972). Maddison compares his own results with those of Denison as follows:

> In my accounting (like that of Jorgenson and Griliches) factor input plays a much bigger role than for Denison. It explains three-quarters of growth whereas for him it represents less than half.[7]

Maddison's critique, like that of Jorgenson and Griliches, underlines the dependence of Denison's most important substantive conclusion, the unimportance of increases in capital input per unit of labor input in explaining growth in output per unit of labor input, on his methodology for the treatment of real capital input.

From our point of view the measurement of real product, real factor input, and total factor productivity is only part of the empirical study of economic growth. In addition, it is necessary to analyze the sources of growth in real factor input, especially growth in capital stock as a component of wealth and growth in capital services as a component of factor input through saving and capital formation. As we have already emphasized, in addition to a production account in current and constant

6. Kendrick (1975), pp. 909–10, has drawn attention to the asymmetry in Denison's (1974) treatment of labor and capital input in his recent study of U.S. economic growth, which is based on the methodology of *Why Growth Rates Differ*.

7. Maddison (1972), p. 40.

prices, this necessitates accounts for income and expenditure, saving and capital formation, and wealth, also in current and constant prices. Logical inconsistencies in the treatment of real capital input would ramify into corresponding inconsistencies in the treatment of taxation and depreciation in the income and expenditure account, the treatment of revaluation and replacement in the saving and capital formation account, and the treatment of capital stock in the wealth account.

The empirical implementation of a complete accounting system necessitates an internally consistent treatment of capital in all four sets of accounts—production, income, saving, and wealth—in current and constant prices. This is a far more stringent requirement than internal consistency of the production account alone, but this requirement is met by the accounting system developed by Christensen and Jorgenson (1973*a*). We have adopted their methodology as the basis for our international comparisons of growth in productivity. The measurement of total factor productivity within a complete accounting system also provides a basis for overcoming a recurrent objection to conventional growth accounting. This objection is that growth of real product, real factor input, and total factor productivity are treated in isolation from other aspects of the process of economic growth, specifically from the determinants of capital formation.

11.1.4 Selection of Countries and Time Periods

Turning next to the selection of a sample of countries, our objective is to compare patterns of aggregate economic growth for the U.S.A. and its major trading partners. This leads immediately to the inclusion of Canada, Japan, and the four largest countries of Western Europe—France, Germany, Italy, and the U.K. Referring again to table 11.1, we find that all six international comparisons of productivity growth include the U.K. and the U.S.A. France and Germany are included in all but one of the studies. Italy is included in three of the six, while Canada and Japan are included in two of the six. Our selection of additional countries has been constrained by the resources available to us.

Our methods for analysis of sources of economic growth can be applied to data for industrialized countries such as Australia, Belgium, Denmark, Finland, the Netherlands, New Zealand, Norway, Sweden, and Switzerland. Among these countries Belgium, Denmark, the Netherlands, Norway, and Sweden have been included in one or more of the studies listed in table 11.1. We have selected the Netherlands for inclusion in our study as the largest of these countries. Work is currently underway on comparable studies for Belgium and Denmark. We have tested the feasibility of applying our methodology to a developing country of importance in trade with the U.S.A. by selecting Korea as a final

addition to our study. Korea also provides comparative perspective for the analysis of patterns of Japanese growth that has proved to be very useful.

The selection of a time period for our study, like the selection of a sample of countries, was constrained by the objectives of our study. To provide the basis for continuing assessments of the impact of policies affecting trade and growth in each country on the pattern of world trade and growth, we require a data base that can be readily updated. These considerations made it necessary to limit our study to the postwar period and to rely as much as possible on official national accounts for the measurement of real product. The starting point for each of our country studies was determined by the first year for which a continuous time series running throughout the postwar period was available. For all nine countries we were able to develop annual time series for the period 1960–73. For all countries except Korea we have developed annual time series for the period 1955–73.

11.2 Methodology

11.2.1 Introduction

Our first objective is to separate growth in real factor input from growth in total factor productivity in accounting for growth in real product for each of the nine countries included in our study. For this purpose we require a methodology for measuring real factor input, real product, and total factor productivity. Our methodology is based on the economic theory of production and technical change. The point of departure for this theory is a production function giving output as a function of inputs and time. We consider production under constant returns to scale, so that a proportional change in all inputs results in a proportional change in output.

In analyzing changes in production patterns we combine the production function with necessary conditions for producer equilibrium. We express these conditions as equalities between shares of each input in the value of output and the elasticity of output with respect to that input. The elasticities depend on inputs and time, the variables that enter the production function. Under constant returns to scale the sum of elasticities with respect to all inputs is equal to unity, so that value shares also sum to unity.

To analyze changes in the pattern of production with time we consider the rate of technical change, defined as the rate of growth of output, holding all inputs constant. The rate of technical change, like the elasticities of output with respect to input, depends on inputs and time. Under constant returns to scale the necessary conditions for producer

equilibrium can be combined with growth rates of inputs and outputs to produce an index of the rate of technical change that depends only on the prices and quantities of inputs and outputs.

11.2.2 Technical Change

Our methodology for productivity measurement is based on the *production function* F, characterized by constant returns to scale:

$$Y = F(K, L, T),$$

where Y is output, K is capital input, L is labor input, and T is time. Denoting the price of output by q_Y, the price of capital input by p_K, and the price of labor input by p_L, we can define the shares of capital and labor input in the value of output, say v_K and v_L, by

$$v_K = \frac{p_K K}{q_Y Y}, \qquad v_L = \frac{p_L L}{q_Y Y}.$$

Necessary conditions for producer equilibrium are given by equalities between each value share and the elasticity of output with respect to the corresponding input:

$$v_K = \frac{\partial \ln Y}{\partial \ln K}(K, L, T),$$

$$v_L = \frac{\partial \ln Y}{\partial \ln L}(K, L, T).$$

Under constant returns to scale the elasticities and the value shares sum to unity.

The production function is defined in terms of output, capital input, and labor input. Output and the two inputs are aggregates that depend on the quantities of individual outputs and inputs. We consider aggregates that are characterized by constant returns to scale, so that proportional changes in all components of each aggregate result in proportional changes in the aggregate:

$$Y = Y(Y_1, Y_2 \ldots Y_m),$$

$$\mathrm{K} = K(K_1, K_2 \ldots K_n),$$

$$L = L(L_1, L_2 \ldots L_p),$$

where $\{Y_i\}$ is the set of outputs, $\{K_j\}$ the set of capital inputs, and $\{L_k\}$ the set of labor inputs.

Denoting the prices of outputs by $\{q_{Yi}\}$, the prices of capital inputs by $\{p_{Kj}\}$, and the prices of labor inputs by $\{p_{Lk}\}$, we can define the shares of individual outputs in the value of output, say $\{w_{Yi}\}$; the shares of individual capital inputs in the value of capital input, say $\{v_{Kj}\}$; and

the shares of individual labor inputs in the value of labor input, say $\{v_{Lk}\}$; by

$$w_{Yi} = \frac{q_{Yi}Y_i}{q_Y Y}, \qquad (i = 1, 2, \ldots, m);$$

$$v_{Kj} = \frac{p_{Kj}K_j}{p_K K}, \qquad (j = 1, 2, \ldots, n);$$

$$v_{Lk} = \frac{p_{Lk}L_k}{p_L L}, \qquad (k = 1, 2, \ldots, p).$$

Necessary conditions for producer equilibrium are given by equalities between value shares and elasticities of the corresponding aggregate with respect to its individual components:

$$w_{Yi} = \frac{\partial \ln Y}{\partial \ln Y_i}, \qquad (i = 1, 2, \ldots, m);$$

$$v_{Kj} = \frac{\partial \ln K}{\partial \ln K_j}, \qquad (j = 1, 2, \ldots, n);$$

$$v_{Lk} = \frac{\partial \ln L}{\partial \ln L_k}, \qquad (k = 1, 2, \ldots, p).$$

Under constant returns to scale the elasticities and the value shares for each aggregate sum to unity.

Finally, we can define the rate of technical change, say v_T, as the growth of output with respect to time, holding capital and labor input constant:

$$v_T = \frac{\partial \ln Y}{\partial T}(K, L, T).$$

Under constant returns to scale the rate of technical change can be expressed as the rate of growth of output less a weighted average of the rates of growth of capital and labor input, where the weights are given by the corresponding value shares:

$$\frac{d \ln Y}{d T} = \frac{\partial \ln Y}{\partial \ln K}\frac{d \ln K}{d T} + \frac{\partial \ln Y}{\partial \ln L}\frac{d \ln Y}{d T} + \frac{\partial \ln Y}{\partial T}$$

$$= v_K \frac{d \ln K}{d T} + v_L \frac{d \ln L}{d T} + v_T.$$

We refer to this expression for the rate of technical change v_T as the *Divisia quantity index of technical change.*

The Divisia quantity index of technical change is defined in terms of aggregates for output, capital input, and labor input. The measurement of productivity begins with data for individual outputs and inputs. Under constant returns to scale the rate of growth of each aggregate

can be expressed as a weighted average of its components, where the weights are given by the corresponding value shares:

$$\frac{d \ln Y}{d T} = \Sigma w_i \frac{d \ln Y_i}{d T},$$

$$\frac{d \ln K}{d T} = \Sigma v_j \frac{d \ln K_j}{d T},$$

$$\frac{d \ln L}{d T} = \Sigma v_k \frac{d \ln L_k}{d T}.$$

We refer to these expressions for aggregate output, capital input, and labor input as the *Divisia indexes of output, capital input, and labor input.*[8]

If the production function F gives output Y as a function of aggregate input, say X, we can write this function in the form

$$Y = G[X(K,L),T],$$

where the function G is homogeneous of degree one in aggregate input X and aggregate input is homogeneous of degree one in capital input K and labor input L, so that technical change is *Hicks-neutral*:

$$Y = A(T)\, X(K,L).$$

The rate of technical change depends only on time:

$$v_T = \frac{d \ln A}{d T},$$

and the rate of growth of aggregate input is a weighted average of rates of growth of capital and labor input:

$$\frac{d \ln X}{d T} = v_K \frac{d \ln K}{d T} + v_L \frac{d \ln L}{d T}.$$

We refer to this expression as the *Divisia index of input.*[9]

Under constant returns to scale a necessary condition for producer equilibrium is that the price of output and the prices of capital and labor

8. These quantity indexes and the analogous price indexes discussed below were introduced by Divisia (1925, 1926). The Divisia index of technical change was introduced by Solow (1957) and discussed by Richter (1966) and by Jorgenson and Griliches (1967).

9. The definition of technical change that is neutral in the sense that it leaves the ratio of marginal products of capital and labor input unchanged is due to Hicks (1963). Hulten (1973) demonstrated that the line integral defining the Divisia index of an aggregate such as input is path independent if and only if the production function is homothetically separable in the components of the aggregate.

inputs are consistent with equality between the value of output and the sum of the values of capital and labor input:

$$q_Y Y = p_K K + p_L L.$$

Given this equality, we can express the price of output as a function, say P, of the prices of capital, labor input, and time:

$$q_Y = P(p_K, p_L, T).$$

We refer to this function as the *price function.*[10] Similarly, we can express the price of each aggregate as a function of the prices of its components.

We can define the rate of technical change as the negative of the growth of the price of output with respect to time, holding the prices of capital and labor input constant:

$$v_T = -\frac{\partial \ln P}{\partial T}(p_K, p_L, T).$$

We can express the rate of technical change as the rate of growth of a weighted average of input prices less the rate of growth of the price of output, where the weights are given by the corresponding value shares:

$$\frac{d \ln q_Y}{d T} = v_K \frac{d \ln p_K}{d T} + v_L \frac{d \ln p_L}{d T} - v_T.$$

We refer to this expression for the rate of technical change as the *Divisia price index of technical change.*

We can express each aggregate price index as a weighted average of its components:

$$\frac{d \ln q_Y}{d T} = \Sigma w_i \frac{d \ln q_{Yi}}{d T},$$

$$\frac{d \ln p_K}{d T} = \Sigma v_j \frac{d \ln p_{Kj}}{d T},$$

$$\frac{d \ln p_L}{d T} = \Sigma v_k \frac{d \ln p_{Lj}}{d T}.$$

We refer to these expressions as *Divisia price indexes of output, capital input, and labor input.* If output is a function of aggregate input, the price of output can be expressed as a function of aggregate input, say p_X, so that

$$q_Y = \frac{p_X(p_K, p_L)}{A(T)},$$

10. The price function was introduced by Samuelson (1953); he refers to this function as the factor-price frontier.

and the rate of growth of the price of aggregate input is a weighted average of rates of growth of the prices of capital and labor input:

$$\frac{d \ln p_X}{d T} = v_K \frac{d \ln p_K}{d T} + v_L \frac{d \ln p_L}{d T}.$$

We refer to this expression as the *Divisia price index of input.*

Divisia indexes have the property that the product of price and quantity indexes for an aggregate is equal to the sum of the values of the components of the aggregate. For example, the product of the price and quantity of aggregate output is equal to the sum of the values of the individual outputs that make up the aggregate. Divisia indexes have the reproductive property that assures consistency among subaggregates, namely, that a Divisia index of Divisia indexes is also a Divisia index. For example, if aggregate output is composed of two subaggregates such as consumption goods and investment goods, the Divisia index of output can be defined, equivalently, as a Divisia index of the components of the two subaggregates or as a Divisia index of Divisia indexes of consumption and investment goods. By duality the reproductive property holds for Divisia price indexes.

11.2.3 Index Numbers

Although Divisia index numbers are useful in relating data on prices and quantities to aggregate output, capital input, and labor input, and to the rate of technical change, our methodology must be extended to include data at discrete points of time. For this purpose we consider a specific form of the production function F:

$$\begin{aligned} Y = \exp [&\alpha_o + \alpha_L \ln L + \alpha_K \ln K + \alpha_T T \\ &+ \tfrac{1}{2}\beta_{KK} (\ln K)^2 + \beta_{KL} \ln K \ln L + \beta_{KT} T \cdot \ln K \\ &+ \tfrac{1}{2}\beta_{LL} (\ln L)^2 + \beta_{LT} \ln L \cdot T + \tfrac{1}{2}\beta_{TT} T^2]. \end{aligned}$$

For this production function output is a transcendental or, more specifically, and exponential function of the logarithms of inputs. We refer to this form as the *transcendental logarithmic production function* or, more simply, the translog production function.[11]

The translog production function is characterized by constant returns to scale if and only if the parameters satisfy the conditions

$$\begin{aligned} \alpha_K + \alpha_L &= 1, \\ \beta_{KK} + \beta_{KL} &= 0, \\ \beta_{KL} + \beta_{LL} &= 0. \end{aligned}$$

11. The translog production function was introduced by Christensen, Jorgenson, and Lau (1971, 1973). The treatment of technical change outlined below is due to Jorgenson and Lau (1977).

The value shares of capital and labor input can be expressed as

$$v_K = \alpha_K + \beta_{KK} \ln K + \beta_{KL} \ln L + \beta_{KT} T,$$

$$v_L = \alpha_L + \beta_{KL} \ln K + \beta_{LL} \ln L + \beta_{LT} T.$$

Finally, the rate of technical change can be expressed as

$$v_T = \alpha_T + \beta_{KT} \ln K + \beta_{LT} \ln L + \beta_{TT} T.$$

If we consider data at any two discrete points of time, say T and $T - 1$, the average rate of technical change can be expressed as the difference between successive logarithms of output less a weighted average of the differences between successive logarithms of capital and labor input with weights given by average value shares:

$$\begin{aligned} \ln Y(T) - \ln Y(T-1) = {} & \bar{v}_K[\ln K(T) \\ & - \ln K(T-1)] \\ & + \bar{v}_L[\ln L(T) - \ln L(T-1)] + \bar{v}_T, \end{aligned}$$

where

$$\bar{v}_K = \tfrac{1}{2}[v_K(T) + v_K(T-1)],$$

$$\bar{v}_L = \tfrac{1}{2}[v_L(T) + v_L(T-1)],$$

$$\bar{v}_T = \tfrac{1}{2}[v_T(T) + v_T(T-1)].$$

We refer to this expression for the average rate of technical change v_T as the *translog index of technical change.*

We can also consider specific forms for the functions defining aggregate output Y, capital input K, and labor input L. For example, the translog form for aggregate output as a function of its components is

$$\begin{aligned} Y = \exp\, [& \alpha_1 \ln Y_1 + \alpha_2 \ln Y_2 + \ldots + \alpha_m \ln Y_m \\ & + \tfrac{1}{2}\beta_{11}(\ln Y_1)^2 + \beta_{12} \ln Y_1 \ln Y_2 + \ldots \\ & + \tfrac{1}{2}\beta_{mm}(\ln Y_m)^2]. \end{aligned}$$

The translog output aggregate is characterized by constant returns to scale if and only if

$$\alpha_1 + \alpha_2 + \ldots + \alpha_m = 1,$$

$$\beta_{11} + \beta_{12} + \ldots + \beta_{1m} = 0,$$

$$\ldots\ldots\ldots\ldots\ldots$$

$$\beta_{1m} + \beta_{2m} + \ldots + \beta_{mm} = 0.$$

The value shares of individual outputs $\{w_{Yi}\}$ can be expressed as

$$w_{Yi} = \alpha_i + \beta_{1i} \ln Y_1 + \ldots + \beta_{im} \ln Y_i, \quad (i = 1, 2, \ldots, m).$$

Considering data at discrete points of time, the difference between successive logarithms of aggregate output can be expressed as a weighted average of differences between successive logarithms of individual outputs with weights given by average value shares:

$$\ln Y(T) - \ln Y(T-1) = \Sigma \bar{w}_{Yi} [\ln Y_i(T) - \ln Y_i(T-1)],$$

where

$$\bar{w}_{Yi} = \tfrac{1}{2}[w_{Yi}(T) + w_{Yi}(T-1)], \quad (i = 1, 2, \ldots, m).$$

Similarly, if aggregate capital and labor input are translog functions of their components, we can express the difference between successive logarithms in the form

$$\ln K(T) - \ln K(T-1) = \Sigma \bar{v}_{Kj} [\ln K_j(T) - \ln K_j(T-1)],$$

$$\ln L(T) - \ln L(T-1) = \Sigma \bar{v}_{Lk} [\ln L_k(T) - \ln L_k(T-1)],$$

where

$$\bar{v}_{Kj} = \tfrac{1}{2}[v_{Kj}(T) + v_{Kj}(T-1)], \quad (j = 1, 2, \ldots, n);$$

$$\bar{v}_{Lk} = \tfrac{1}{2}[v_{Lk}(T) + v_{Lk}(T-1)], \quad (k = 1, 2, \ldots, p).$$

We refer to these expressions for aggregate output, capital input, and labor input as *translog indexes of output, capital input, and labor input.*[12]

To define price indexes corresponding to translog indexes of aggregate output, capital input, and labor input, we employ the fact that the

12. The quantity indexes were introduced by Fisher (1922) and discussed by Tornquist (1937), Theil (1965), and Kloek (1966). These indexes of output and input were first derived from the translog production function by Diewert (1976). The corresponding index of technical change was introduced by Christensen and Jorgenson (1970). The translog index of technical change was first derived from the form of the translog production function given above by Jorgenson and Lau (1977). The approach developed by Jorgenson and Lau does not require the assumption of Hicks neutrality. Diewert had interpreted the ratio of translog indexes of output and input as an index of technical change under the assumption of Hicks neutrality.

product of price and quantity indexes for each aggregate must be equal to the sum of the values of the components of the aggregate. For example, the price index for aggregate output is defined as the ratio of the sum of the values of the individual outputs to the translog output index. Price indexes for capital and labor input can be defined in a strictly analogous way. Although the resulting aggregate price indexes do not have the form of translog index numbers, these price indexes are nonetheless well defined. Each aggregate price index can be determined solely from data on prices and quantities of the components of the aggregate. By definition, the product of price and quantity indexes for an aggregate is equal to the sum of the values of its components. However, these indexes do not have the reproductive property that a translog index of translog indexes remains a translog index. The translog index for an aggregate depends on the structure of the subaggregates on which it is defined.[13]

11.2.4 Productivity Change

Our methodology for separating growth in real factor input from growth in total factor productivity is based on translog index numbers of aggregate output, capital input, labor input, and technical change. These index numbers provide a direct connection between the economic theory of production and technical change and data on prices and quantities of output and input at discrete points of time. We find it useful to develop further implications of our methodology for data on capital and labor input. The measurement of capital input begins with data on the stock of capital for each component of capital input. Similarly, the measurement of labor input begins with data on hours worked for each component of labor input. It is important to be explicit about the relationship between these data and the aggregates for capital and labor input defined by translog index numbers.

For a single type of capital input we first characterize the relative efficiency of capital goods of different ages by means of a sequence of nonnegative numbers—$d(0), d(1), \ldots$. We normalize the efficiency of a new capital good at unity,

$$d(0) = 1,$$

so that the remaining elements in the sequence represent the efficiency of capital goods of every age relative to the efficiency of a new capital good. We assume that relative efficiency is nonincreasing with age, say τ, so that

$$d(\tau) - d(\tau - 1) \leqslant 0, \qquad (\tau = 1, 2, \ldots),$$

13. This corrects an error in Christensen and Jorgenson (1973*a*), p. 261.

and that every capital good is eventually retired or scrapped, so that relative efficiency eventually drops to zero:

$$\lim_{\tau \to \infty} d(\tau) = 0.$$

The stock of capital, say $A(T)$, is the sum of past investments, say $I(T - \tau)$, each weighted by relative efficiency:

$$A(T) = \sum_{\tau=0}^{\infty} d_\tau I(T - \tau).$$

Similarly, the price of acquisition of new capital goods, say $p_I(T)$, is the discounted value of the future prices of capital input, say $p_K(T + \tau)$, weighted by relative efficiency:

$$p_I(T) = \sum_{\tau=0}^{\infty} d_\tau \prod_{S=1}^{\tau} \frac{1}{1 + r(T + S)} p_K(T + \tau + 1),$$

where $r(T)$ is the *rate of return on capital* in period T and $\Pi^{\tau}_{S=1}$ $[1/1 + r(T + S)]$ is the discount factor in period T for future prices in period $T + S$.

Using data on decline in efficiency, estimates of capital stock can be compiled from data on prices and quantities of investment in new capital goods at every point of time by means of the perpetual inventory method.[14] We assume that relative efficiency of capital goods declines geometrically with age:

$$d_\tau = (1 - \delta)^\tau, \qquad (\tau = 0, 1, \ldots).$$

Under this assumption capital stock is a weighted sum of past investments with geometrically declining weights:

$$A(T) = \sum_{\tau=0}^{\infty} (1 - \delta)^\tau I(T - \tau).$$

Similarly, the price of investment goods is a weighted sum of future prices of capital input with the same weights:

$$p_I(T) = \sum_{\tau=0}^{\infty} (1 - \delta)^\tau \prod_{S=1}^{\tau} \frac{1}{1 + r(T + S)} p_K(T + \tau + 1).$$

14. The perpetual inventory method has been employed by Goldsmith (1955) and in the BEA Capital Stock Study (1976). The dual to the perpetual inventory method, involving investment goods prices and capital input prices, was introduced by Christensen and Jorgenson (1969, 1973*a*). For further discussion of the underlying model of durable capital goods, see Jorgenson (1973).

Capital stock at the end of each period is equal to investment during the period less a constant proportion δ of capital stock at the beginning of the period:

$$A(T) = I(T) - \delta A(T-1).$$

Similarly, the price of capital input is equal to the sum of the nominal return to capital $p_I(T-1)\, r(T)$ and depreciation $\delta p_I(T)$, less revaluation $p_I(T) - p_I(T-1)$:

$$p_K(T) = p_I(T-1)r(T) + \delta p_I(T) - [p_I(T) - p_I(T-1)].$$

We can also express the price of capital input as the sum of the price of investment $p_I(T-1)$ multiplied by the *own rate of return on capital*

$$r(T) - \frac{p_I(T) - p_I(T-1)}{p_I(T-1)}$$

and depreciation:

$$p_K(T) = p_I(T-1)\left[r(T) - \frac{p_I(T) - p_I(T-1)}{p_I(T-1)}\right] + \delta\, p_I(T).$$

Second, for each of the components of capital input $\{K_j(T)\}$ the flow of capital services is proportional to the stock of capital at the end of the preceding period, say $\{A_j(T-1)\}$:

$$K_j(T) = Q_{Kj}A_j(T-1), \qquad (j = 1, 2, \ldots, n),$$

where the constants of proportionality $\{Q_{Kj}\}$ transform capital stock into a flow of capital services per period of time. For example, the flow of capital services from a group of machines is measured as the services of the machines per period of time while the stock of capital is measured as the number of machines. The flow of capital services reflects the own rate of return to capital and the rate of depreciation, both expressed per period of time, as well as the quantity of capital stock. The flow of services per unit of stock varies from one type of capital to another, so that the constants $\{Q_{Kj}\}$ can be taken as measures of the quality of capital stock in producing capital services.

The translog index of aggregate capital input can be expressed in terms of its components or in terms of capital stocks:

$$\ln K(T) - \ln K(T-1) = \Sigma \bar{v}_j[\ln K_j(T) - \ln K_j(T-1)],$$
$$= \Sigma \bar{v}_j[\ln A_j(T-1) - \ln A_j(T-2)].$$

If we define the stock of capital at the beginning of the preceding time period, say $A(T-1)$, as a translog index of its components,

$$\ln A(T-1) - \ln A(T-2) = \Sigma \bar{v}_{Aj}[\ln A_j(T-1) - \ln A_j(T-2)],$$

with weights given by the value shares of the individual capital stocks $\{v_{Aj}\}$ and

$$\bar{v}_{Aj} = \tfrac{1}{2}[v_{Aj}(T-1) + v_{Aj}(T-2)], \qquad (j = 1, 2, \ldots, n).$$

We define an *index of the quality of capital stock*, say $Q_K(T)$, that transforms the translog index of capital stock into the translog index of capital input:

$$K(T) = Q_K(T)\, A(T-1).$$

Our index of the quality of capital stock can be expressed in the form

$$\ln Q_K(T) - \ln Q_K(T-1) = \Sigma \bar{v}_j[\ln A_j(T-1) - A_j(T-2)] - [\ln A(T-1) - \ln A(T-2)],$$

so that this index reflects changes in the composition of capital. If all components of capital stock are growing at the same rate, quality remains unchanged. If components with higher flows of capital input per unit of stock are growing more rapidly, quality will increase. If components with lower flows per unit of stock are growing more rapidly, quality will decline.

Second, for each of the components of labor input $\{L_k(T)\}$ the flow of labor services is proportional to hours worked, say $\{H_k(T)\}$:

$$L_k(T) = Q_{Lk} H_k(T), \qquad (k = 1, 2, \ldots, p),$$

where the constants of proportionality $\{Q_{Lk}\}$ transform hours worked into a flow of labor services per period of time. The flow of services varies from one type of labor to another, so that the constants $\{Q_{Lk}\}$ can be taken as measures of the quality of hours worked in producing labor services.

The translog index of aggregate labor input can be expressed in terms of its components or in terms of hours worked:

$$\ln L(T) - \ln L(T-1) = \Sigma \bar{v}_k[\ln L_k(T) - \ln L_k(T-1)], = \Sigma \bar{v}_k[\ln H_k(T) - \ln H_k(T-1)].$$

If we define hours worked, say $H(T)$, as the unweighted sum of its components,

$$H(T) = \Sigma H_k(T),$$

we can define an *index of the quality of hours worked*, say $Q_L(T)$, that transforms hours worked into the translog index of labor input:

$$L(T) = Q_L(T)\, H(T).$$

Our index of the quality of hours worked can be expressed in the form

$$\begin{aligned}\ln Q_L(T) - \ln Q_L(T-1) &= \Sigma \bar{v}_k[\ln H_k(T) - \ln H_k(T-1)] \\ &\quad - [\ln H(T) - \ln H(T-1)],\end{aligned}$$

so that this index reflects changes in the composition of hours worked. Quality remains unchanged if all components of hours worked are growing at the same rate. Quality rises if components with higher flows of labor input per hour worked are growing more rapidly and falls if components with lower flows of input per hour are growing more rapidly.

We have decomposed the rate of growth of the translog index of aggregate output into the sum of a weighted average of the rates of growth of translog indexes of aggregate capital and labor input and the rate of technical change. Using the indexes of capital and labor quality, we can decompose the rate of growth of output as follows:

$$\begin{aligned}&\ln Y(T) - \ln Y(T-1) \\ &= \bar{v}_k[\ln K(T) - \ln K(T-1)] + \bar{v}_L[\ln L(T) \\ &- \ln L(T-1)] + \bar{v}_T \\ &= \bar{v}_K[\ln Q_K(T) - \ln Q_K(T-1)] + \bar{v}_K[\ln A(T-1) \\ &- \ln A(T-2)] + \bar{v}_L[\ln Q_L(T) - \ln Q_L(T-1)] \\ &+ \bar{v}_L[\ln H(T) - \ln H(T-1)] + \bar{v}_T.\end{aligned}$$

The rate of growth of output is the sum of a weighted average of the rates of growth of capital stock and hours worked, a weighted average of the rates of growth of quality of capital stock and hours worked, and the rate of technical change.

11.3 Production Account

11.3.1 Introduction

Our next objective is to identify output, capital input, labor input, and technical change with accounts for real product, real capital input, real labor input, and total factor productivity for each of the nine countries included in our study. It is important to emphasize that only the translog indexes of output, capital input, labor input, and technical change can be derived from the theoretical model of production we have presented in section 11.2. The stock of capital, the number of hours worked, and the indexes of quality of capital stock and hours worked are purely descriptive measures. Similarly, the index of total input is a descriptive measure unless we assume that technical change is Hicks-neutral. This assumption is not required in constructing production accounts for each country in this section or in the international and intertemporal comparisons given in section 11.4 below. Wherever we provide comparisons in terms of real factor input, corresponding comparisons can be provided in terms of real product and total factor productivity without using an index of total input.

In this section we outline the principles we have followed in constructing production accounts for the nine countries in our study. A description of the complete accounting system and details of its empirical implementation for the U.S.A. can be found in Christensen and Jorgenson (1973*a*). A brief description of the sources and methods used to construct the production account for each country is contained in the Appendix. Our summary of sources and methods is based on detailed reports on the data construction for each country. These reports are listed among our references and are available from the authors. The Appendix also includes annual time series of real product, real capital input, real labor input, and total factor productivity for each country.

11.3.2 Product and Factor Outlay

The starting point for the construction of translog indexes of output and technical change is the measurement of the value of total product and the value of total factor outlay in current prices. The fundamental accounting identity for the production account is that the value of total product equals the value of total factor outlay. We exclude indirect business taxes unrelated to factor outlay, such as retail sales taxes and excise taxes, from the value of total product; however, indirect business taxes which are part of the outlay on factor services, such as property taxes, are retained in the value of total factor outlay and total product. Our concept of output is intermediate between output at market prices and output at factor cost.

The production account in a complete system of national economic accounts includes the activities of the private sector, the government sector, and the rest of the world. In analyzing productive activity and its distribution between consumption and investment on the output side and between capital and labor on the input side we have limited the scope of our production account to the private domestic sector of each country. Rest of the world production is excluded on the grounds that it can reflect a different physical and social environment for productive activity than the environment provided for the domestic sector.

The boundary between private and government activity varies from country to country within our study, because of variations in the role of government enterprises. While government administration must be excluded from our private domestic production account, essentially similar economic activities—telecommunications, transportation, and public utilities—are conducted by government enterprises and by private enterprises. For some of the countries included in our study it is impossible to obtain separate accounts for government and private enterprises. For the United States, on the other hand, the government enterprises are treated in a manner that is more closely analogous to the treatment of government administration than to the treatment of private enterprises. No capital accounts are maintained for government enterprises and government administration separately. Of course, government enterprises produce an almost negligible proportion of the gross national product of the U.S.A. To provide international comparability in the scope of our product measure we have included government enterprise product for all countries.

The inclusion of government enterprises in gross private domestic product should not result in confusion since "private" gross national product includes government enterprises in the official national income and product accounts of all nine countries. One unconventional aspect of our measure of total output is an imputation for the services of consumer durables. Our objective is to attain consistency in the treatment of owner-occupied residential structures and owner-utilized consumer durable equipment. It is standard procedure for national income accounts to include an imputation for owner-occupied housing in national product but not to include an analogous imputation for consumer durables. Our measure of total input is gross private domestic factor outlay, which is equal to gross private domestic product. Table 11.A.1 gives (for each country) a complete reconciliation of gross private domestic product and factor outlay with gross national product and national income.[15]

15. There are four appendix tables for each country, numbered 11.A.1 through 11.A.4. Table 11.A.1C is table 11.A.1 for Canada, and so on.

The product and factor outlay accounts are linked through capital formation and the compensation of property. To make this link explicit we divide total output between consumption and investment goods and total factor outlay between labor and property compensation. We include all services and nondurable goods in consumption goods; we include all structures and producer and consumer durable equipment in investment goods. Data for the U.S.A. are available for a complete separation of gross private domestic product between consumption goods and investment goods. For all nine countries it has been possible to separate gross private domestic product between consumption goods and investment goods, except for inventory investment and net exports. In table 11.A.2 we present time series for gross private domestic product. We also present time series for consumption goods product and investment goods product. Inventory investment and net exports are presented separately for countries where they could not be allocated between consumption goods and investment goods. The value shares of investment goods product for each country are presented in table 11.2.

To divide total factor outlay between labor and property compensation, it is necessary to allocate the factor outlay for self-employed persons between labor and property compensation. We have used the method of Christensen (1971) to impute labor compensation to self-employed workers. This involves assigning the estimated wage rate for employees to the self-employed. Christensen has shown that for the U.S.A. this method results in an allocation which is consistent with the assumption that after-tax rates of return are equal in the corporate and noncorporate sectors. The resulting division of gross private domestic factor outlay into labor and property compensation is presented in table 11.A.2 for all nine countries. The value shares of property compensation for each country are presented in table 11.3.

11.3.3 Real Capital Input

The starting point for the computation of a translog quantity index of capital input is a perpetual inventory estimate of the stock of each type of capital, based on past investments in constant prices. At each point of time the stock of each type of capital is the sum of past investments weighted by relative efficiency. Under the assumption that the efficiency of capital goods declines geometrically, the rate of replacement for the jth capital good, say δ_j, is a constant. Capital stock at the end of each period can be estimated from investment during the period and capital stock at the beginning of the period:

$$A_j(T) = I_j(T) + (1 - \delta_j)A_j(T - 1), \qquad (i = 1, 2, \ldots, n).$$

Table 11.2 Value Share of Investment Goods Product, 1947–73

Year	Canada	France	Germany	Italy	Japan	Korea	Nether-lands	United Kingdom	United States
1947	.275								.281
1948	.294								.308
1949	.300								.290
1950	.307	.243	.304						.340
1951	.294	.255	.324				.251		.340
1952	.297	.249	.336	.247	.298		.243		.321
1953	.299	.242	.321	.252	.271		.272		.317
1954	.296	.249	.339	.258	.274		.279		.306
1955	.302	.262	.368	.266	.295		.297	.213	.337
1956	.327	.264	.362	.267	.334		.310	.216	.334
1957	.332	.272	.365	.277	.372		.322	.223	.327
1958	.313	.274	.359	.272	.322		.300	.227	.298
1959	.306	.272	.363	.278	.351		.316	.235	.318
1960	.297	.276	.386	.289	.389	.126	.325	.238	.301
1961	.292	.287	.391	.300	.450	.133	.326	.238	.295
1962	.300	.292	.396	.305	.414	.152	.326	.233	.306
1963	.309	.294	.390	.309	.421	.161	.319	.234	.310
1964	.313	.309	.414	.290	.429	.139	.342	.253	.311
1965	.326	.311	.422	.269	.408	.169	.341	.251	.318
1966	.336	.317	.398	.263	.414	.227	.340	.246	.318
1967	.329	.317	.358	.269	.443	.232	.343	.253	.305
1968	.330	.319	.389	.276	.458	.270	.348	.257	.308
1969	.324	.326	.412	.281	.463	.282	.334	.250	.304
1970	.324	.327	.424	.284	.482	.264	.349	.254	.293
1971	.321	.331	.420	.284	.469	.250	.347	.258	.298
1972	.323	.333	.409	.280	.460	.224	.333	.255	.305
1973	.323	.333	.405	.281	.486	.265	.329	.264	.308

We have compiled time series of capital stock estimates for seven asset classes: consumer durables, nonresidential structures, producer durable equipment, residential structures, nonfarm inventories, farm inventories, and land. For each of the seven asset classes we derive perpetual inventory estimates of the stock as follows: First, we obtain a benchmark estimate of capital stock from data on national wealth in constant prices. Second, we deflate the investment series from the national income and product accounts to obtain investment in constant prices. Third, we choose an estimate of the rate of replacement from data on lifetimes of capital goods. Finally, we estimate capital stock in every period by applying the perpetual inventory method as outlined in section 11.2 above.

Each type of capital stock can be valued in current prices by using an index of the acquisition prices for new capital goods. We employ the investment goods price indexes to convert stocks of assets in constant prices to stocks of assets in current prices. These values can be employed in estimating value shares by class of assets. The value shares and stocks can be combined to obtain a translog quantity index of aggregate capital stock. The price index of capital stock is obtained by dividing the value of all assets by the translog quantity index. The price and quantity indexes of private domestic capital stock are presented in table 11.A.3. Value shares of the seven assets in each country are presented for 1970 in table 11.4.

To construct translog price and quantity indexes of capital input we require value shares of individual capital inputs in total property compensation and stocks of individual assets. In the absence of taxation the value of the jth capital input is the sum of depreciation and the own return to capital, defined as the nominal return less revaluation:

$$p_{Kj}(T)K_j(T) = \{p_{Ij}(T-1)r(T) + p_{Ij}(T)\delta_j - [p_{Ij}(T) - p_{Ij}(T-1)]\}A_j(T-1) \quad (j = 1, 2, \ldots, n).$$

Given property compensation, the stock of assets, the price of acquisition of capital stock, and the rate of depreciation, we can determine the nominal rate of return. The nominal rate of return is equal to the ratio of property compensation less depreciation plus revaluation of assets to the value of capital stock at the beginning of the period.

In measuring the rate of return, differences in tax treatment of property compensation must be taken into account. For tax purposes the private domestic sector can be divided into corporate business, noncorporate business, and households and nonprofit institutions. Households and institutions are not subject to direct taxes on the flow of capital services which they utilize. Noncorporate business is subject to personal

Table 11.3 Value Share of Capital Input, 1947–73

Year	Canada	France	Germany	Italy	Japan	Korea	Nether-lands	United Kingdom	United States
1947	.346								.368
1948	.376								.378
1949	.397								.381
1950	.413	.439	.340						.389
1951	.406	.387	.348				.474		.403
1952	.430	.376	.368	.419	.382		.480		.402
1953	.426	.396	.361	.420	.334		.467		.389
1954	.418	.386	.358	.394	.335		.469		.390
1955	.449	.381	.371	.403	.336		.483	.385	.401
1956	.443	.372	.369	.399	.351		.482	.370	.395
1957	.423	.377	.373	.400	.362		.468	.379	.386
1958	.441	.360	.369	.402	.346		.454	.381	.394
1959	.444	.366	.386	.407	.362		.459	.386	.401
1960	.444	.389	.396	.409	.391	.326	.465	.385	.400
1961	.447	.385	.389	.418	.433	.393	.448	.381	.404
1962	.448	.384	.379	.415	.401	.385	.443	.378	.408
1963	.460	.387	.385	.389	.398	.401	.437	.389	.412
1964	.470	.394	.395	.379	.422	.422	.432	.387	.415
1965	.467	.398	.400	.385	.402	.395	.432	.384	.421
1966	.462	.431	.400	.396	.415	.383	.416	.383	.428
1967	.440	.436	.405	.390	.431	.323	.424	.389	.425
1968	.442	.432	.423	.391	.442	.340	.433	.394	.418
1969	.436	.441	.421	.404	.441	.333	.422	.386	.414
1970	.434	.443	.413	.374	.436	.355	.413	.371	.404
1971	.441	.435	.405	.332	.409	.341	.415	.387	.401
1972	.430	.439	.409	.331	.405	.354	.421	.405	.410
1973	.470	.439	.404	.329	.396	.378	.410	.404	.418

Table 11.4 **Value Shares of Capital Stock by Asset Class, 1970**

	Canada	France	Germany	Italy	Japan	Korea	Nether-lands	United Kingdom	United States
Consumer Durables	.106	.067	.076	.081	.055	.024	.094	.086	.137
Nonresidential Structures	.233	.150	.193	.180	.376	.140	.192	.205	.157
Producer Durables	.156	.198	.222	.173		.114	.206	.316	.136
Residential Structures	.200	.276	.294	.371	.188	.146	.253	.168	.216
Nonfarm Inventories	.067	.111	.078	.077	.139	.058	.091	.105	.077
Farm Inventories	.017					.032		.019	.012
Land	.222	.198	.136	.117	.243	.485	.163	.101	.263

income taxes on income generated from capital services, while corporate business is subject to both corporate and personal income taxes. Households and corporate and noncorporate business are subject to indirect taxes on property income through taxes levied on the value of property. In order to take these differences into account we allocate each class of assets among the four sectors. For all countries, households and institutions have been treated separately from the business sector; for some of the countries it was not possible to separate the corporate and noncorporate sectors.

Property compensation associated with assets in the household sector is not taxed directly; however, part of the income is taxed indirectly through property taxes. To incorporate property taxes into our indexes of the price and quantity of capital services we add property taxes to the return to capital and depreciation in the definition of the value of the jth capital input:

$$p_{Kj}(T)K_j(T) = \{p_{Ij}(T-1)r(T) + p_{Ij}(T)\delta_j - [p_{Ij}(T) - p_{Ij}(T-1)] + p_{Ij}(T)t_j(T)\}A_j(T-1) \quad (j = 1, 2, \ldots, n),$$

where t_j is the rate of property taxation. The nominal rate of return is the ratio of property compensation less depreciation plus revaluation of capital assets less property taxes to the value of capital stock at the beginning of the period.

Given the nominal rate of return for households and institutions, we can construct estimates of capital input prices for each class of assets held by households and institutions—land held by households and institutions, residential structures, nonresidential structures, producer durables, and consumer durables. These estimates require acquisition prices for each capital good, rates of replacement, rates of property taxation for assets held by households, and the nominal rate of return for the sector as a whole. We employ separate effective tax rates for owner-occupied residential property, both land and structures, and for consumer durables. Finally, we combine the price and quantity of capital input for each class of asset into a translog index of capital input for households and institutions.

To obtain an estimate of the noncorporate rate of return we deduct property taxes from noncorporate property compensation, add revaluation of assets, subtract depreciation, and divide the result by the value of noncorporate assets at the beginning of the period. The noncorporate rate of return is gross of personal income taxes on noncorporate property compensation. Property compensation of households and institutions is not subject to the personal income tax. The value of property compensation in the noncorporate sector is equal to the value of the

flow of capital services from residential and nonresidential structures, producer durable equipment, farm and nonfarm inventories, and land held by the sector. All farm inventories are assigned to the noncorporate sector. Given the noncorporate rate of return, estimated from noncorporate property compensation by the method outlined above, and given data on prices of acquisition, stocks, tax rates, and replacement rates for each class of assets, we can estimate capital input prices for each class of assets. Price and quantity data are combined into a translog index of the quantity of capital input for the noncorporate sector.

We next consider the measurement of prices and quantities of capital input for corporate business. To obtain an estimate of the corporate rate of return we must take into account the corporate income tax. For the U.S.A. the value of capital input for the corporate sector, modified to incorporate the corporate income tax and indirect business taxes, becomes

$$p_{Kj}(T)K_j(T) = \left(\left[\frac{1 - u(T)z_j(T) - k_j(T) + y_j(T)}{1 - u(T)}\right]\right.$$
$$\times \{p_{Ij}(T-1)r(T) + p_{Ij}(T)\delta_j$$
$$\left. - [p_{Ij}(T) - p_{Ij}(T-1)]\} + p_{Ij}(T)t_j(T)\right)$$
$$\times A_j(T-1) \qquad (j = 1, 2, \ldots, n),$$

where $u(T)$ is the corporate tax rate, $z_j(T)$ is the present value of depreciation allowances on one dollar's investment, $k_j(T)$ is the investment tax credit, and $y_j(T) = k_j(T)u(T)z_j(T)$ for 1962 and 1963 and zero for all other years. The tax credit is different from zero only for producers' durables. Depreciation allowances are different from zero only for producers' durables and structures. For other countries this formula has been adopted in order to reflect the corporate tax structure in each country.

Our method for estimating the corporate nominal rate of return is the same as for the noncorporate nominal rate of return. Property compensation in the corporate sector is the sum of the value of services from residential and nonresidential structures, producer durable equipment, nonfarm inventories, and land held by that sector. To estimate the nominal rate of return in the corporate sector we require estimates of the variables that describe the corporate tax structure—the effective corporate tax rate, the present value of depreciation allowances, and the investment tax credit. We obtain estimates of all the variables—acquisition prices and stocks of assets, rates of replacement, and variables describing the tax structure—that enter the value of capital input except, of course, for the nominal rate of return. We then determine the nomi-

nal rate of return from these variables and total corporate property compensation.

To estimate the nominal rate of return in the corporate sector our first step is to subtract property taxes from total property compensation before taxes. The second step is to subtract corporate profits tax liability. We then add revaluation of assets, subtract depreciation, and divide the result by the value of corporate assets at the beginning of the period. The corporate rate of return is gross of personal income taxes, but net of the corporate income tax. We estimate the price of capital input for each asset employed in the corporate sector by substituting the corporate rate of return into the corresponding formula for the price of capital input. These formulas also depend on acquisition prices of capital assets, rates of replacement, and variables describing the tax structure. Data on the stock of each class of assets are constructed by the perpetual inventory method. Price and quantity data of capital input by class of asset are combined into a translog index of the quantity of capital input for the corporate sector.

It is interesting to compare the rate of return on capital over time and across countries. In table 11.5 we present own rates of return for the business sector. These rates of return are computed as a weighted average of own rates of return on corporate and noncorporate assets, using the value of assets at the beginning of the period in each sector as weights. Own rates of return are adjusted for differences in rates of inflation over time and across countries. Capital input prices depend only on own rates of return. Nominal rates of return for the business sector are presented in table 11.A.3 for each country included in our study.

The price and quantity index numbers for capital input in the various sectors can be combined into a price and quantity index for the private domestic sector. The quantity index is a translog index number, and the price index is defined as the ratio of property compensation to the quantity index. The price and quantity indexes of private domestic capital input are presented in table 11.A.3. Growth rates of real capital input computed from quantity indexes in table 11.A.3 are presented for each country in table 11.6. The quality of capital is defined as the ratio of the quantity index of capital services to the quantity index of capital stock. The quality of capital index is also presented in table 11.A.3.

11.3.4 Real Product and Factor Input

To construct a quantity index of labor input, it would be desirable to use the formula for a translog labor index for a large number of skill classifications. Classifications could be defined by level of education, sex, age, occupation, and so on. Following Jorgenson and Griliches (1967), we have limited our consideration to a single skill measure—

Table 11.5 Own Rate of Return to Capital in the Business Sector, 1947–73

Year	Canada	France	Germany	Italy	Japan	Korea	Nether-lands	United Kingdom	United States
1947	.057								.078
1948	.068								.079
1949	.072								.063
1950	.070	.093	.053						.066
1951	.058	.069	.065				.057		.071
1952	.073	.058	.071	.049	.044		.045		.059
1953	.066	.066	.065	.057	.030		.053		.052
1954	.053	.063	.067	.050	.037		.066		.052
1955	.066	.062	.082	.063	.048		.072	.071	.061
1956	.075	.059	.079	.063	.057		.067	.072	.050
1957	.059	.059	.079	.063	.056		.065	.071	.048
1958	.061	.050	.073	.068	.042		.056	.067	.049
1959	.060	.049	.079	.073	.052		.061	.072	.051
1960	.055	.064	.087	.078	.072	.059	.067	.081	.046
1961	.050	.061	.079	.088	.102	.091	.057	.081	.049
1962	.055	.062	.069	.086	.079	.083	.055	.073	.059
1963	.060	.061	.067	.075	.085	.144	.050	.081	.061
1964	.064	.066	.072	.062	.108	.182	.057	.089	.063
1965	.067	.066	.074	.067	.092	.138	.054	.085	.072
1966	.066	.081	.069	.077	.107	.137	.046	.078	.077
1967	.053	.081	.061	.080	.129	.093	.051	.079	.068
1968	.054	.081	.075	.080	.144	.103	.053	.081	.062
1969	.046	.088	.075	.092	.138	.108	.053	.069	.054
1970	.049	.085	.079	.074	.137	.098	.051	.057	.046
1971	.047	.080	.070	.046	.109	.099	.046	.065	.048
1972	.045	.083	.067	.042	.105	.102	.047	.066	.055
1973	.065	.083	.064	.035	.101	.128	.044	.058	.058

Table 11.6 **Annual Rates of Growth of Real Private Domestic Capital Input, 1947–73**

Year	Canada	France	Germany	Italy	Japan	Korea	Nether-lands	United Kingdom	United States
1948	.092								.067
1949	.072								.063
1950	.071								.042
1951	.083	.054	.043						.067
1952	.073	.042	.052				.026		.054
1953	.066	.039	.070	.019	.014		.004		.037
1954	.074	.044	.068	.027	—.003		.021		.039
1955	.049	.048	.075	.027	.016		.052		.032
1956	.064	.051	.088	.034	.017		.055	.053	.052
1957	.080	.055	.080	.038	.078		.064	.035	.042
1958	.065	.052	.077	.040	.119		.062	.040	.034
1959	.049	.045	.073	.037	.054		.035	.044	.018
1960	.048	.042	.069	.042	.069		.041	.051	.034
1961	.043	.054	.082	.055	.109	.006	.061	.056	.031
1962	.036	.059	.079	.066	.157	.013	.071	.049	.023
1963	.041	.064	.079	.070	.113	.027	.073	.039	.034
1964	.045	.066	.067	.078	.089	.039	.063	.046	.039
1965	.054	.070	.077	.049	.117	.037	.073	.060	.043
1966	.065	.061	.084	.036	.089	.031	.074	.051	.053
1967	.068	.064	.066	.039	.083	.088	.062	.041	.057
1968	.054	.060	.041	.052	.117	.113	.057	.043	.044
1969	.049	.059	.055	.049	.140	.132	.059	.045	.046
1970	.051	.067	.071	.053	.138	.127	.060	.034	.046
1971	.037	.064	.076	.060	.148	.096	.076	.035	.031
1972	.044	.062	.073	.049	.123	.090	.067	.047	.035
1973	.052	.064	.062	.046	.116	.054	.062	.059	.045

educational attainment. This results in a quality of labor index which we apply to total man-hours in the private domestic sector. In table 11.A.4 we present the components of real labor input for the private domestic sector. The first column gives total persons engaged in production. The second column gives average hours worked per person engaged. The quality index is presented in the third column. The product of the first three columns provides the quantity index for private domestic labor input. The quantity index is scaled to equal labor compensation in the base year. The ratio of labor compensation to the quantity index gives the price index for private domestic labor input. Growth rates of real labor input computed from quantity indexes in table 11.A.4 are presented in table 11.7.

The quantity indexes of private domestic capital and labor input can be combined into a translog quantity index of private domestic factor input. The price index is then computed as the ratio of the value of private domestic input to the quantity index. The price and quantity indexes are presented for each country in table 11.A.5. Growth rates of real factor input computed from the quantity indexes in table 11.A.5 are presented in table 11.8.

Given measures of total product in current prices, the remaining task is to separate these data into price and quantity components. Total product is first divided between investment goods and consumption goods. These components of total product are separated into price and quantity components using deflators from the national income and product accounts. The quantity indexes for consumption and investment goods are then combined using translog index numbers. Price indexes are constructed so that the product of price and quantity indexes equals the current dollar magnitude. Since inventory investment and net exports can be negative, quantity indexes are added to the quantity index of consumption and investment goods to obtain the quantity index of gross private domestic product. For each country the price and quantity indexes of gross private domestic product are presented in table 11.A.5. Growth rates of real product computed from quantity indexes in table 11.A.5 are presented for each country in table 11.9. Finally, an index of total factor productivity, defined as the ratio of real product to real factor input, is presented for each country in table 11.A.5. Growth rates of total factor productivity computed from the data in table 11.A.5 are presented in table 11.10.

11.4 International Comparisons

11.4.1 Introduction

Our international comparisons are based on growth of output, input, and total factor productivity for the nine countries included in our study.

Table 11.7 Annual Rates of Growth of Real Private Domestic Labor Input, 1947–73

Year	Canada	France	Germany	Italy	Japan	Korea	Nether-lands	United Kingdom	United States
1948	.013								.016
1949	.017								−.039
1950	−.019								.038
1951	.020	.016	.030						.044
1952	.011	−.006	.022				−.006		.010
1953	.014	−.007	.029	.032	.049		.024		.017
1954	−.005	.010	.035	.038	.027		.024		−.034
1955	.017	.003	.044	−.001	.040		.023		.035
1956	.043	.005	.015	−.001	.077		.020	.005	.021
1957	.014	.010	−.014	.018	.049		.006	−.020	−.008
1958	−.015	−.007	−.009	.002	.035		−.006	−.012	−.027
1959	.031	−.006	−.006	.009	.046		.020	.024	.041
1960	.010	.015	.012	.027	.059		.025	.014	.013
1961	−.021	.004	−.000	.009	.013	.061	−.029	.022	−.005
1962	.029	.007	−.016	−.022	.022	.019	.026	.002	.028
1963	.017	.008	−.016	.009	.026	.041	.021	.014	.016
1964	.031	.013	.012	−.035	.030	−.002	.013	.018	.021
1965	.032	−.006	−.008	−.069	.043	.106	.014	−.002	.037
1966	.027	.012	−.019	.027	.027	.030	.011	−.013	.038
1967	.019	−.002	−.058	.034	.038	.057	−.018	−.015	.015
1968	.002	−.007	.018	.013	.034	.079	.014	−.000	.024
1969	.019	.017	.016	−.020	.014	.063	.016	.005	.032
1970	−.001	.008	.006	.019	.018	.002	−.004	−.027	−.011
1971	.019	−.002	−.022	−.025	.012	.066	−.001	−.053	.006
1972	.027	−.003	−.016	−.026	.014	.064	−.018	.010	.038
1973	.054	.007	−.003	−.004	.033	.066	−.004	.038	.050

Table 11.8 Annual Rates of Growth of Real Private Domestic Factor Input, 1947–73

Year	Canada	France	Germany	Italy	Japan	Korea	Nether-lands	United Kingdom	United States
1948	.042								.035
1949	.038								−.000
1950	.017								.040
1951	.046	.032	.034						.054
1952	.037	.012	.033				.009		.027
1953	.036	.011	.044	.026	.036		.015		.025
1954	.028	.023	.047	.034	.017		.023		−.005
1955	.031	.020	.055	.010	.032		.037		.034
1956	.052	.022	.042	.013	.056		.037	.023	.033
1957	.043	.027	.021	.026	.059		.034	.001	.011
1958	.020	.014	.023	.017	.064		.025	.007	−.003
1959	.039	.013	.024	.020	.048		.027	.032	.032
1960	.027	.025	.034	.033	.063		.032	.028	.022
1961	.007	.023	.032	.028	.052	.041	.012	.035	.010
1962	.032	.027	.021	.015	.078	.017	.046	.020	.026
1963	.028	.029	.020	.034	.061	.035	.044	.024	.023
1964	.038	.034	.034	.008	.054	.015	.035	.029	.028
1965	.042	.024	.026	−.024	.073	.077	.039	.022	.040
1966	.044	.033	.022	.030	.052	.030	.038	.011	.045
1967	.041	.027	−.008	.036	.057	.068	.015	.007	.033
1968	.025	.022	.028	.028	.071	.090	.032	.017	.033
1969	.032	.036	.033	.007	.070	.086	.034	.020	.038
1070	.022	.034	.033	.032	.071	.045	.023	−.004	.012
1971	.028	.027	.019	.005	.069	.077	.031	−.020	.016
1972	.035	.026	.020	−.001	.059	.073	.017	.025	.037
1973	.053	.032	.024	.012	.066	.062	.024	.046	.048

Table 11.9 Annual Rates of Growth of Real Gross Private Domestic Product, 1947–73

Year	Canada	France	Germany	Italy	Japan	Korea	Nether-lands	United Kingdom	United States
1948	.035								.054
1949	.054								.007
1950	.097								.095
1951	.039	.025	.099						.066
1952	.090	.031	.082				.015		.037
1953	.059	.080	.085	.087	.095		.075		.046
1954	−.006	.050	.079	.036	.064		.069		−.010
1955	.087	.053	.121	.082	.103		.072		.072
1956	.095	.046	.081	.047	.043		.054	.023	.024
1957	.027	.058	.066	.045	.097		.036	.026	.016
1958	.025	.015	.041	.056	.069		−.053	.010	.000
1959	.042	.050	.076	.065	.069		.100	.046	.058
1960	.029	.084	.095	.064	.112		.080	.061	.022
1961	.015	.053	.055	.084	.178	.052	.035	.050	.023
1962	.060	.063	.040	.060	.106	.029	.045	.015	.056
1963	.055	.058	.041	.047	.109	.097	.033	.039	.039
1964	.069	.076	.072	.034	.119	.063	.096	.072	.053
1965	.071	.054	.063	.034	.095	.071	.062	.025	.060
1966	.066	.058	.035	.056	.076	.123	.035	.028	.060
1967	.029	.050	.000	.073	.114	.084	.049	.031	.027
1968	.053	.044	.078	.055	.125	.118	.071	.039	.045
1969	.043	.081	.070	.061	.113	.177	.067	.010	.031
1970	.038	.061	.071	.053	.123	.074	.067	.037	−.001
1971	.050	.047	.031	−.026	.093	.087	.052	.034	.035
1972	.050	.054	.044	.028	.084	.089	.062	.051	.063
1973	.066	.067	.060	.061	.081	.191	.050	.068	.063

Table 11.10 Annual Rate of Growth of Total Factor Productivity

Year	Canada	France	Germany	Italy	Japan	Korea	Nether-lands	United Kingdom	United States
1948	—.007								.018
1949	.016								.008
1950	.080								.055
1951	—.007	—.006	.064						.012
1952	.053	.019	.050				.005		.010
1953	.023	.069	.041	.061	.058		.061		.021
1954	—.034	.027	.032	.002	.047		.046		—.004
1955	.056	.033	.066	.072	.071		.034		.038
1956	.043	.024	.038	.034	—.014		.017	—.001	—.009
1957	—.016	.031	.045	.019	.038		.002	.025	.005
1958	.005	.001	.018	.039	.004		—.079	.002	.003
1959	.003	.037	.052	.044	.020		.073	.014	.026
1960	.003	.059	.061	.031	.049		.047	.033	.000
1961	.008	.030	.023	.056	.125	.011	.022	.015	.014
1962	.028	.036	.020	.045	.028	.012	—.002	—.005	.031
1963	.027	.029	.021	.013	.048	.062	—.011	.015	.015
1964	.032	.043	.038	.026	.065	.048	.061	.043	.025
1965	.029	.030	.037	.058	.022	—.006	.022	.003	.021
1966	.022	.025	.013	.025	.024	.093	—.003	.016	.015
1967	—.012	.023	.008	.037	.057	.016	.034	.025	—.006
1968	.029	.021	.051	.027	.054	.028	.038	.023	.013
1969	.010	.045	.038	.054	.043	.091	.033	—.010	—.007
1970	.016	.027	.038	.020	.053	.029	.044	.041	—.013
1971	.023	.019	.013	—.031	.024	.010	.021	.055	.019
1972	.016	.029	.024	.029	.025	.015	.045	.026	.026
1973	.013	.035	.037	.048	.015	.129	.027	.022	.015

In section 11.3 we have presented annual rates of growth of real gross private domestic product, real gross private domestic factor input, and total factor productivity for all nine countries.[16] We have also presented rates of growth of real capital input and real labor input for these countries. In this section we first compare growth in real factor input and in total factor productivity as sources of growth in real product. We then compare growth in real capital input and in real labor input as sources of growth in real factor input. Finally, we compare our analysis of aggregate economic growth with an analysis based on measures of capital and labor input that do not incorporate changes in the quality of capital stock and the quality of hours worked.

Annual growth rates of real product, real capital input, real labor input, and total factor productivity are available for all nine countries included in our study for the period 1960–73, so that we can compare patterns of aggregate economic growth across countries for this period. For all countries except Korea annual growth rates are available for periods ending in 1960 and beginning at various times from 1947 to 1955, so that we can compare patterns of aggregate economic growth between time periods for each country except for Korea. Since the earlier periods vary in length from country to country we do not attempt to make systematic comparisons of growth patterns across countries for periods before 1960–73.

11.4.2 Aggregate Economic Growth

We present average annual growth rates for real product, real factor input, total factor productivity, real capital input, and real labor input in table 11.11. This table provides average annual growth rates for all nine countries included in our study for the period 1960–73. Our international comparisons of patterns of aggregate economic growth are based on growth in real product, real factor input, and total factor productivity for all nine countries for this period. Table 11.11 also includes average annual growth rates for all countries except for Korea for earlier periods beginning between 1947 and 1955 and ending in 1960. Our intertemporal comparisons of growth patterns are based on data for the period 1960–73 and for the earlier periods.

During the 1960–73 period, average growth rates of real product fell within the relatively narrow range of 4.3% to 5.9% for six of the nine countries included in our study. For the two North American countries, Canada and the U.S.A., average growth rates of real product were 5.1% and 4.3%, respectively. For four of the European countries—France, Germany, Italy, and the Netherlands—average growth rates were 5.9%,

16. All annual growth rates presented in this paper are computed as first differences of natural logarithms.

Table 11.11 **Average Annual Growth Rates of Real Product, Real Factor Input, Total Factor Productivity, Real Capital Input, and Real Labor Input**

	Canada	France	Germany	Italy	Japan	Korea	Nether-lands	United Kingdom	United States
					1960–73				
Real Product	.051	.059	.054	.048	.109	.097	.056	.038	.043
Real Factor Input	.033	.029	.024	.016	.064	.055	.030	.018	.030
Total Factor Productivity	.018	.030	.030	.031	.045	.041	.026	.021	.013
Real Capital Input	.049	.063	.070	.054	.115	.066	.066	.046	.040
Real Labor Input	.020	.004	−.007	−.007	.027	.050	.003	.000	.022
	1947–60	1950–60	1950–60	1952–60	1952–60		1951–60	1955–60	1947–60
Real Product	.052	.049	.082	.060	.081		.050	.033	.037
Real Factor Input	.035	.020	.036	.023	.047		.027	.018	.023
Total Factor Productivity	.017	.029	.047	.038	.034		.023	.015	.014
Real Capital Input	.068	.047	.069	.033	.045		.040	.045	.045
Real Labor Input	.011	.003	.016	.016	.048		.014	.002	.010

5.4%, 4.8%, and 5.6%. Growth of real product for the U.K., the fifth European country, fell below this range with an average rate of 3.8%. For the two Asian countries, Japan and Korea, growth of real product greatly exceeded this range with average rates of 10.9% and 9.7%, respectively.

Among the six countries characterized by moderate growth of real product, the range of variation in average growth rates of real factor input is the same as for real product. For France, Germany, Italy, and the Netherlands the average growth rates of real factor input are 2.9%, 2.4%, 1.6%, and 3.0%, respectively, for the period 1960–73. For this period the average rate of growth of real factor input for Canada is 3.3% and for the U.S.A. is 3.0%. By contrast, the high-growth countries, Japan and Korea, had the highest average rates of growth of real factor input, 6.4% and 5.5%, respectively. The low-growth country, the U.K., had the lowest average rate of growth in real factor input at 1.8%.

Our first conclusion is that variations in average growth rates of real product among countries during the period 1960–73 are associated with variations in growth rates of real factor input. This conclusion is based on all possible comparisons between growth rates of real product and real factor input for pairs of countries. For twenty-eight of the thirty-six possible comparisons, the differences of growth rates of real product have the same sign as the differences of growth of real factor input. For example, a comparison of patterns of economic growth for the period 1960–73 for France and the U.K. reveals average rates of growth of real product of 5.9% and 3.8%, respectively. These growth rates are associated with average rates of growth of real factor input of 2.9% and 1.8%.

If we compare patterns of aggregate economic growth between the period 1960–73 and earlier periods for each country included in our study, except for Korea, we find that average growth rates of real product have increased for France, Japan, the Netherlands, the U.K., and the U.S.A., while average growth rates have decreased for Canada, Germany, and Italy. For every country with an increased average rate of growth of real product, the average rate of growth of real factor input has also increased or remained the same. The most dramatic increases are for Japan, where the average growth rate of real product rose from 8.1% for the period 1952–60 to 10.9% for the period 1960–73, while the average growth rate of real factor input rose from 4.7% for the earlier period to 6.4% for the later period. At the opposite end of the spectrum of growth rates in real product, the rate of growth of real product for the U.K. rose modestly from 3.3% for the period 1955–60 to 3.8% for the period 1960–73, while the rate of growth of real factor input remained virtually unchanged at 1.8% for both periods.

Among countries with decreases in the average rate of growth of real product, the greatest change was for Germany with a decline from 8.2% for the period 1950–60 to 5.4% during the period 1960–73. The average growth rate of real factor input dropped from 3.6% to 2.4% between the two periods. For Canada the growth rate of real product dropped from 5.2% for the period 1947–60 to 5.1% for 1960–73, while the growth rate of real factor input dropped from 3.5% to 3.3% between the two periods. For Italy the average rate of growth of real product declined from 6.0% for the period 1952–60 to 4.8% for 1960–73, while the growth rate of real factor input declined from 2.3% for the earlier period to 1.6% for the later period. Our second conclusion is that increases and decreases in average growth rates of real factor input between the period 1960–73 and various earlier periods beginning from 1947 to 1955 and ending in 1960 are strongly associated with increases and decreases in average growth rates of real product for all eight countries for which data are available.

The most striking illustration of the association of growth of real factor input and growth in real product is provided by a comparison of patterns of aggregate economic growth for Germany and Japan. During the period 1950–60 Germany had an average rate of growth of real product of 8.2%, while for the period 1952–60 Japan had an average rate of growth of real product of 8.1%. For the period 1960–73 the average growth rate of real product rose from the earlier period for Japan to 10.9%, while the average growth rate for Germany fell to 5.4%. For Japan the average growth rate of real factor input rose from 4.7% for the earlier period to 6.4% for the 1960–73 period, while the average growth rate for Germany fell from 3.6% to 2.4%.

11.4.3 Growth in Capital and Labor Input

In analyzing the growth of real factor input among countries or between time periods for a given country, we first recall that the rate of growth of real factor input is a weighted average of rates of growth of real capital input and real labor input, with weights given by the value shares of each input. We give value shares for capital input together with ratios of the average weighted rate of growth of capital input, the average weighted rate of growth of labor input, and the average rate of growth of total factor productivity to the average rate of growth of real product in table 11.12. The rate of growth of each input is weighted by the value share of that input. Table 11.12 provides data for all nine countries included in our study for the period 1960–73, and for all countries except Korea for earlier periods ending in 1960.

Value shares for capital input vary within a narrow range from .367 for Korea to .449 for Canada for the period 1960–73, so that variations in weights assigned to capital and labor input do not account for much

Table 11.12 **Value Share of Capital Input and Contributions of Growth in Real Capital Input, Real Labor Input, and Total Factor Productivity to Growth in Real Product**

	Canada	France	Germany	Italy	Japan	Korea	Nether-lands	United Kingdom	United States
					1960–73				
Capital Value Share	.449	.417	.401	.383	.415	.367	.429	.387	.414
Contributions of:									
Real Capital Input	.430	.444	.520	.435	.437	.250	.509	.468	.393
Real Labor Input	.209	.043	−.074	−.090	.147	.329	.031	−.006	.306
Total Factor Productivity	.361	.513	.556	.659	.414	.429	.460	.538	.301
	1947–60	1950–60	1950–60	1952–60	1952–60		1951–60	1955–60	1947–60
Capital Value Share	.420	.382	.367	.405	.352		.470	.380	.393
Contributions of:									
Real Capital Input	.549	.365	.310	.220	.197		.381	.513	.469
Real Labor Input	.127	.039	.120	.155	.380		.155	.042	.160
Total Factor Productivity	.325	.595	.568	.627	.421		.465	.445	.375

variation in average rates of growth of real factor input across countries. However, average rates of growth of real capital and labor input do vary substantially among countries as indicated in table 11.11. For the European countries the rate of growth of labor input ranges from a negative .7% for Italy to a positive .4% for France. Average rates of growth of labor input for Canada and the United States are 2.0% and 2.2%, respectively, while average rates of growth of labor input are 2.7% for Japan and 5.0% for Korea.

Comparing average rates of growth of real capital input among countries for the period 1960–73, we find that Japan and Germany have the highest average rates of growth with 11.5% and 7.0%, respectively. Canada, the U.K., and the U.S.A. have relatively low average rates of growth—4.9%, 4.6%, and 4.0%. For the remaining countries of Europe the average growth rates of capital input are higher than for the U.K. and the two North American countries, and lower than for Japan and Germany. Average rates of growth for France, Korea, Italy, and the Netherlands are 6.3%, 6.6%, 5.4%, and 6.6%.

Our third conclusion is that for the period 1960–73 very high average growth rates in real product are associated with high average rates of growth of both capital and labor input, and that low average rates of growth in real product are associated with low average rates of growth of both inputs. Average rates of growth of real product in the moderate range from 4½ to 6%, which includes five of the nine countries in our study, can be associated either with low average growth rates for labor and high growth rates for capital, as in Germany, or with high average growth rates for labor and low growth rates for capital, as in the United States. There are substantial variations among countries in average rates of growth of both capital and labor input, so that further analysis requires a study of the sources of growth of capital input through the supply of saving and capital formation and the sources of growth of labor input through the supply of work effort.

We find it useful to illustrate our third conclusion by comparing the economic performance of the U.K. and the U.S.A. for the period 1960–73. The average rate of growth of real product is higher for the U.S.A. at 4.3% than for the U.K. at 3.8%. Average rates of growth of real factor input are 3.0% for the U.S.A. and 1.8% for the U.K. Turning to average growth rates of real capital input and real labor input, we find that the difference in rates of growth of real factor input can be accounted for by the difference in average rates of growth of real labor input, zero for the U.K. and 2.2% for the U.S.A. The average rate of growth of capital input for the U.K. of 4.6% exceeded that for the U.S.A. of 4.0%. The average rate of growth of total factor productivity for the U.K. of 2.1% also exceeded that for the U.S.A. of 1.3%. The difference in average rates of growth of real labor input in the two

countries accounts almost entirely for the difference in average rates of growth of real product.

If we compare the growth of real factor input between the time period 1960–73 and earlier periods we first observe that the greatest change in value shares of capital input is to .415 for the period 1960–73 from .352 for the earlier period for Japan. Changes in value shares of capital input between time periods do not account for much variation in average rates of growth of real factor input between time periods. For five of the eight countries included in our intertemporal comparisons, the value share of capital input increases between the earlier periods and the period 1960–73. If technical change were Hicks-neutral, this would imply an average elasticity of substitution in excess of unity for these five countries, since the rate of growth of capital input exceeds the rate of growth of labor input for all countries and all periods except for Japan for the period 1952–60.

Comparing the average rates of growth of real capital input and real labor input between time periods for a given country, we find that Japan's average rate of growth of real labor input for the period 1952–60 was 4.8%, while the average rate of growth of real capital input was only 4.5% for this period. For the period 1960–73 the average rate of growth of labor input declined to 2.7%, still high by international standards, while the average rate of growth of capital input jumped to 11.5%. The improvement in Japan's economic performance was due almost entirely to the increased average rate of growth of real capital input.

For Germany the decline in the average growth rate of real labor input from 1.6% during the period 1950–60 to —.7% from 1960–73 was as large as the decline for Japan from the period 1952–60 to the later period. The average rate of growth of capital input rose from 6.9% for 1950–60 to 7.0% for 1960–73, and the average rate of growth of real product fell from 8.2% in the earlier period to 5.4% in the later period. The decline in Germany's economic performance was due primarily to the decreased average rate of growth of real labor input. The contrast with changes in Japan's economic performance between 1960–73 and the earlier period is due to differences in the increase of the average rate of growth of capital input.

Our fourth conclusion is that a rise or fall in the average rate of growth of real labor input is associated with a fall or rise in the rate of growth of real capital input. This pattern reflects the process of substitution between capital and labor input in production. Germany and Japan provide the most striking illustrations of this pattern, with substantial changes in aggregate economic growth between 1960–73 and the earlier periods. However, the same pattern can be seen for two

countries with moderate changes in aggregate economic growth—Canada and the U.S.A. The average rate of growth of real capital input fell from 6.8% to 4.9% for Canada, and from 4.5% to 4.0% for the U.S.A. between the periods 1947–60 and 1960–73. Average growth rates of labor input rose from 1.1% to 2.0% for Canada, and from 1.0% to 2.2% for the U.S.A. for the same two periods. France is the only exception to the general pattern; average rates of growth of real labor input and real capital input rose from .3% to .4% and from 4.7% to 6.3% between the periods 1950–60 and 1960–73.

A second illustration of our fourth conclusion involves a comparison of Korean growth for the period 1960–73 with Japanese growth for the period 1952–60. Average growth rates of real labor input were 4.8% for Japan and 5.0% for Korea. Korea had an average rate of growth of capital input at 6.6%, while Japan's average rate of growth was only 4.5%. Korea's average rate of growth of real product for the later period was 9.7%, compared with Japan's rate of growth of 8.1% for the earlier period. Korea's average rate of growth of total factor productivity for the later period was 4.1%, while for Japan in the earlier period the average was 3.4%. The difference in average rates of growth of capital inputs accounts for the bulk of the difference in economic performance.

11.4.4 Quality Change

Up to this point we have compared patterns of economic growth in terms of growth of real product, real factor input, real capital input, and real labor input. We can provide additional perspective on these results by contrasting our analysis of growth patterns and an analysis based on measures of capital and labor input that fail to incorporate changes in capital and labor quality. In table 11.13 we present average annual rates of growth of capital quality, labor quality, capital stock, and hours worked. We recall that the rate of growth of real capital input is the sum of the rates of growth of capital quality and capital stock. Similarly, the rate of growth of real labor input is the sum of the rates of growth of labor quality and hours worked.

Quality change for both capital and labor input is positive for all countries and for all time periods included in our study, except change in capital quality for Germany for the period 1952–60. An analysis based on measures of capital and labor input that fail to incorporate changes in the quality of capital stock and hours worked would assign growth in total factor productivity a much larger role in accounting for the growth in real product. For the period 1960–73 growth in total factor productivity is more important than growth in real factor input in accounting for growth in real product for four countries—France,

Table 11.13 **Average Annual Growth Rates of Quality of Capital Stock, Capital Stock, Quality of Hours Worked, and Hours Worked**

	Canada	France	Germany	Italy	Japan	Korea	Nether-lands	United Kingdom	United States
					1960–73				
Quality of Capital Stock	.011	.012	.005	.004	.030	.027	.020	.004	.010
Capital Stock	.038	.051	.066	.050	.085	.039	.046	.042	.030
Quality of Hours Worked	.005	.004	.001	.013	.006	.012	.005	.006	.008
Hours Worked	.015	.000	−.010	−.020	.022	.038	−.002	−.006	.014
	1947–60	1950–60	1950–60	1952–60	1952–60		1951–60	1955–60	1947–60
Quality of Capital Stock	.017	.009	−.000	.002	.013		.009	.010	.009
Capital Stock	.051	.038	.070	.031	.033		.031	.035	.035
Quality of Hours Worked	.006	.005	.001	.002	.002		.005	.006	.007
Hours Worked	.006	−.002	.011	.013	.046		.009	−.004	.003

Germany, Italy, and the U.K. Similarly, for earlier periods growth in total factor productivity is more important for three countries—France, Germany, and Italy.

If we were to replace our translog index of real labor input by hours worked as a measure of labor input and our translog index of real capital input by capital stock as a measure of capital input, total factor productivity would be more important than growth in factor input for every country and every time period included in our study, except for Japan during the period 1952–60. Our fifth conclusion is that omission of changes in quality of capital stock and hours worked would result in a completely distorted view of the relative importance of growth in real factor input and growth in total factor productivity in accounting for the growth of real product.

If we compare the role of change in quality of capital stock and hours worked between the period 1960–73 and earlier periods, we find that the differences are relatively modest except for Japan. The growth of real factor input for Japan for the period 1960–73 is 6.4%, the highest for any country and any time period included in our study. The difference between the average rate of growth in real factor input for Japan and the average rates of growth of real factor input for the remaining countries included in our study is the most important factor in accounting for the differences in rates of growth of real product between Japan and the remaining countries. The average rate of growth of real product for Japan was 10.9%, also the highest for any country and any time period included in our study. Similarly, the difference between the average rate of growth of real factor input during the period 1952–60 of 4.7% and the higher rate for the later period is an important factor in accounting for the increase in the average rate of growth from 8.1% during the earlier period.

Finally, we can analyze the role of quality change in our measures of real capital input and real labor input. Japan and Korea have the highest rates of growth of hours worked and of real labor input for the period 1960–73. A ranking based on real labor input would coincide with a ranking based on hours worked. However, the growth of hours worked is negative or zero for all five European countries, while the growth of our translog index of real labor input is nonnegative except for Germany and Italy. Omission of change in quality of hours worked from the measurement of labor input would result in a change in sign in the average rate of growth of labor input for four of the five European countries included in our study.

Growth in the quality of capital stock for Japan during the period 1960–73 is 3.0%, the highest for any country in our study. The rise in the average rate of growth of capital quality from 1.3% during the period 1962–60 is an important factor in accounting for the rise in the

average rate of growth of real capital input from 4.5% in the earlier period to 11.5% in the later period. Our final conclusion is that differences among countries are greater for change in capital quality than for change in labor quality, but that omission of either results in a distortion of the relative importance of growth of real capital input and real labor input in accounting for growth in real product.

11.5 Summary and Conclusions

In section 11.2 we have outlined a methodology for separating growth in real factor input from growth in total factor productivity, based on the transcendental logarithmic production function. Beginning with a production function that gives output as a function of capital input, labor input, and time, we have defined translog indexes of output, capital input, labor input, and technical change in terms of data on prices and quantities of output and inputs at discrete points of time. We have also introduced descriptive measures of the quality of capital stock and hours worked that transform indexes of capital stock and hours worked into translog indexes of capital and labor input. These descriptive measures are useful in comparing the results of our analysis with the results of studies that fail to incorporate quality change in measures of capital and labor input.

In section 11.3 we have identified translog indexes of output, capital input, labor input, and technical change with accounts for real product, real capital input, real labor input, and total factor productivity for each of the nine countries included in our study. For all countries we have constructed annual production accounts in current and constant prices for the period 1960–73. For all countries except Korea we have constructed annual production accounts for various earlier periods, beginning from 1947 to 1955 and ending in 1960. Our first objective has been to assess the relative importance of growth in real factor input and in total factor productivity in accounting for patterns of aggregate economic growth for all nine countries for the period 1960–73. Our second objective has been to assess the relative importance of changes in growth in real factor input and in total factor productivity in accounting for changes in growth of real product between earlier periods ending in 1960 and the period 1960–73 for each country.

Our first conclusion is that variations in aggregate economic growth for the period 1960–73 for the nine countries included in our study are associated with variations in the growth of real factor input. This conclusion is strongly reinforced by a comparison of patterns of aggregate economic growth for this period with growth during earlier periods ending in 1960 for each country except Korea. An analysis that fails to incorporate changes in the quality of capital stock and hours worked

in measures of capital and labor input would assign a much larger role to variations in growth of total factor productivity in accounting for international variations in the growth of real product or for variations in growth of real product over time for a given country.

The second objective of our analysis has been to assess the role of growth in real capital input and in real labor input in accounting for aggregate economic growth. For the period 1960–73 we find that very rapid growth of real product is associated with rapid growth of both real capital input and real labor input, and that slow growth of real product is associated with slow growth of both inputs. Moderate growth of real product can be associated with rapid growth of real capital input, rapid growth of real labor input, or moderate rates of growth of both inputs. Our intertemporal comparisons show that increases and decreases in the average rate of growth of real capital input are associated with decreases and increases, respectively, in the average rate of growth of real labor input. This finding provides evidence of substitution between capital and labor inputs in production.

Omission of changes in the quality of capital stock and hours worked from our measures of capital and labor input would obscure the role of differences in the growth of capital and labor input in accounting for differences in the growth of output among countries and between time periods for a given country. Further analysis of international and intertemporal differences in the growth of capital input and the growth of labor input requires a detailed characterization of sources of growth of these inputs. A complete system of accounts, like that developed by Christensen and Jorgenson (1973*a*), is essential to the analysis of sources of growth of capital input through saving, capital formation, and accumulation of wealth. An analysis of the sources of growth in labor input through the supply of work effort is also required. The analysis of sources of growth in capital and labor input remains an important objective for further research on patterns of aggregate economic growth.

Appendix

Canada

This summary is taken from Christensen and Cummings (1976).

Our principal data sources for Canada are the *National Income and Expenditure Accounts, Historical Revision, 1926–1971* and the recent annual issues of the *National Income and Expenditure Accounts*, both published by Statistics Canada. Except for the imputation for services

of consumer durables, gross private domestic product and factor outlay are computed directly from these sources.

The capital stock benchmarks and replacement rates for all assets except residential structures and consumer durables are taken from Statistics Canada (1974), *Flows and Stocks of Fixed Nonresidential Capital, Canada.* The residential structures and consumer durables benchmarks are from Gussman (1972). The replacement rate for residential structures is from Cummings and Meduna (1973), and the replacement rate for consumer durables is our estimate. We estimate the benchmark and price index for land using Danielson (1975) and Manvel (1968). Asset deflators are from the national accounts.

Our data on employment are from the *National Income and Expenditure Accounts, Historical Revision* and annual issues of the *Bank of Canada Review*. The Productivity Measures Project, Input Output Division, Statistics Canada provided us with data for average hours worked per person employed and labor income of self-employed persons. We have constructed an educational attainment index using the educational distributions in the 1941, 1951, 1961, and 1971 censuses of Canada, published by Statistics Canada.

France

This summary is taken from Brazell, Christensen, and Cummings (1975).

Our principal data sources for France are the *National Accounts Statistics* and *Les comptes de la nation 1949–1959*, both published by the Institut national de la statistique et des études économiques. Gross private domestic product and factor outlay are computed directly from these sources, except for our estimates of the inventory valuation adjustment, the services of consumer durables, and the services of institutional durables and real estate.

The nonresidential structures and producer durable equipment benchmarks are from Mairesse (1972), the residential structures benchmark is from Carré, Dubois, and Malinvaud (1972), and the inventory benchmark is from Goldsmith and Saunders (1959). We estimate the benchmark for land using Goldsmith and Saunders (1959). Our land price index is an average European land price index based on Christensen et al. (1975), Christensen, Cummings, and Norton (1975), Christensen, Cummings, and Schoeck (1975), and Conrad and Jorgenson (1975). The replacement rates for nonresidential structures and producers' durable equipment are from Mairesse (1972), and the consumer durables and residential structures replacement rates are our estimates. The asset deflators are from the national accounts.

The data on employment are from Carré, Dubois, and Malinvaud (1972), the Institut national de la statistique et des études économiques

(*National Accounts Statistics* and "La population active par secteur d'établissement"), and the Ministère des affaires sociales, *Revue française du travail*. Average hours worked are computed from *Annuaire statistique de la France* and various other publications of the Institut national de la statistique et des études économiques, plus information on average weeks of vacation from Carré, Dubois, and Malinvaud (1972). The educational attainment index is computed from data in the French Population Census and Carré, Dubois, and Malinvaud (1972).

Germany

This summary is taken from Conrad and Jorgenson (1975).

Our principal data source for the Federal Republic of Germany is the national income and product accounts, as published by the Statistisches Bundesamt. Except for the imputation for services of consumer durables, gross private domestic product and factor outlay are computed from these accounts.

The capital stock benchmarks are from Kirner (1968) and Stobbe (1969). The replacement rates are based on service lives estimated by Kirner (1968). The asset deflators are from the national income and product accounts.

We use estimates of man-hours compiled by the Statistisches Bundesamt. The educational attainment index is based on Denison (1967). It has been updated using information published by the Statistisches Bundesamt.

Italy

This summary is taken from Christensen, Cummings, and Norton (1979).

Our principal data source for Italy is the *Annuario di contabilita nazionale* published by the Istituto Centrale di Statistica. Except for the imputation for services of consumer durables, gross private domestic product and factor outlay are computed directly from this source.

The capital stock benchmarks for nonresidential structures, producers' durable equipment, and residential structures are from Vitali (1968); the inventory benchmark is from A. Giannone (1963); and the land benchmark is based on the work of de Meo (1973). The consumer durable benchmark and replacement rate are our estimates. The other replacement rates are from de Meo (1973). The investment deflators are from the national accounts except for land and inventories. We use a wholesale price index as the inventory deflator, and the land deflator is based on de Meo (1973).

Our data on employment are from *Annali di statistica* published by the Istituto Centrale di Statistica and *Labor Force Statistics* published by the OECD. Average hours per person employed are from *Rassegna*

di statistiche del lavoro published by the Istituto Centrale di Statistica. Our educational attainment index is constructed using information from the *Ninth Census of Italy* (Istituto Centrale di Statistica, 1951), *National Policies for Education, Italy* (OECD 1960, 1963, 1966), and Denison (1967).

Japan

This summary is taken from Ezaki and Jorgenson (1973) and Ezaki (1974).

Our principal data source for Japan is *Annual Report on National Income Statistics* published by the Economic Planning Agency. Except for the imputation for consumer durables, gross private domestic product and factor outlay are computed from these accounts.

The capital stock benchmarks are taken from the 1955 and 1960 national wealth surveys. The replacement rates are based on service lives estimated by Ohkawa et al. (1966). The asset deflators are from the national income and product accounts, except for the land deflator, which is based on data from the *Japanese Statistical Yearbook.*

We use estimates of man-hours made available to us by Dr. Yoichi Okita of the Economic Planning Agency. The quality of labor index is based on the work of Watanabe (1972).

Korea

This summary is taken from Christensen and Cummings (1979).

Our principal data sources for Korea are the *Economic Statistics Yearbook* and the *National Income Statistics Yearbook* published by the Bank of Korea. In addition, the Bank of Korea provided us with the unpublished data which we required. Except for the imputation for services of consumer durables, gross private domestic product and factor outlay are computed directly from Bank of Korea data.

The capital stock benchmarks for nonresidential structures, producers' durable equipment, and residential structures are from the *Report on the National Wealth Survey* of the Economic Planning Board. The benchmark for land is from Mills and Song (1977). The benchmark for consumer durables and the replacement rates for all asset types are our estimates. The investment deflators are from the Economic Statistics Yearbook except for inventories and land. The inventory deflator is a wholesale price index, and the land deflator is based on the work of Mills and Song (1977).

The Economic Planning Board provided us with unpublished data on employment and average hours worked to supplement the published figures in the *Labor Statistics Yearbook.* The educational attainment index is based on data in the *Population and Housing Census* (1960,

1966, 1970) and the *Report on Wage Survey* (1967, 1970), both published by the Economic Planning Board.

Netherlands

This summary is taken from Christensen, Cummings, and Schoech (1975).

Our principal data source for the Netherlands is the Centraal bureau voor de statistiek (1956, 1960, 1965, 1972) and the National Accounts (1950–68, 1953–69, 1960–71, 1961–72, 1962–73) published by the OECD. Except for the imputation for services of consumer durables, gross private domestic product and factor outlay are computed directly from these sources.

The capital stock benchmarks, except that for consumer durables, are from Goldsmith and Saunders (1959). The capital stock benchmark for consumer durables is our estimate. The replacement rate for consumer durables is also our estimate. All other replacement rates are based on the replacement rates used by the Centraal bureau voor de statistiek. The asset deflators are all from the OECD National Accounts except for the inventory deflator which comes from *Maandschrift van het centraal bureau voor de statistiek* (1954, 1959, 1964, 1967, 1969, 1972, 1973) and the land deflator. We estimate our own land deflator using Statistical Yearbook of the Netherlands, Goldsmith and Saunders (1959), and Revell (1967).

We use the estimate of man-years compiled by the Centraal bureau voor de statistiek (1947–66) and the Nationale rekenigen (1972–73). The number of hours worked per week is taken from data provided by the International Labour Organization (1947 through 1973). The educational attainment index is derived from Denison (1967).

United Kingdom

This summary is taken from Christensen, Cummings, and Singleton (1975).

Our principal data sources for the United Kingdom are *National Income and Expenditure, 1963–1973* and earlier issues of *National Income and Expenditure* (annual volumes from 1954 through 1966), both published by the Central Statistical Office (CSO). Except for the imputation for services of consumer durables, gross private domestic product and factor outlay are computed directly from these sources.

The capital stock benchmarks for nonresidential structures, residential structures, plant and machinery, vehicles, ships and aircraft, and inventories are taken from the CSO, *National Income and Expenditure* volume. The consumer durable benchmark is our estimate. The replacement rate for nonresidential structures is taken from the Inland Revenue

Service. The replacement rates for plant and machinery and residential structures are from *The Stock of Fixed Capital in the United Kingdom in 1961* by Geoffrey Dean. The benchmark and price index for land are estimated using J. Revell, *The Wealth of the Nation*; *Inland Revenue Statistics*, published by the Board of Inland Revenue; and CSO, *Annual Abstract of Statistics*.

Our data on employment are from the CSO, *National Income and Expenditure* volumes, except for the number of self-employed, which is taken from OECD, *Labor Force Statistics*. Our average hours worked per person is taken from *British Labour Statistics, Year Books* and the *British Labour Statistics: Historical Abstract, 1886–1968*, both published by the Department of Employment. We use the rate of growth of educational attainment estimated by R.C.O. Matthews (1975).

United States

This summary is taken from Christensen and Jorgenson (1973*a*).

Our principal data source for the United States is U.S. Office of Business Economics (1966) and the Annual National Income issue (July) of the *Survey of Current Business* published by the U.S. Department of Commerce. Except for the imputations for services of durables held by consumers and institutions, gross private domestic product and factor outlay are computed directly from these sources.

The capital stock benchmarks are from Grose, Rottenberg, and Wasson (1969) and Goldsmith (1962). The replacement rates are based on estimated service lives underlying the work by Grose, Rottenberg, and Wasson (1969). The asset deflators are all from the Bureau of Economic Analysis, except for the land deflator, which is based on Goldsmith (1962).

We use estimates of man-hours compiled by Kendrick (1973), and the index of educational attainment computed by Jorgenson and Griliches (1967). The underlying sources are the U.S. Bureau of Labor Statistics, *Special Labor Force Reports*, and the U.S. Bureau of the Census, *Census of Population and Current Population Reports*.

Table 11.A.1C Gross Private Domestic Product and Factor Outlay, 1970

Canada
(billions of dollars)

	Product	
1.	Gross national product	85.69
2.	— Wages and salaries in general government	11.02
3.	— Capital consumption allowances in general government	1.23
4.	— Net interest and miscellaneous investment income of general government (net of government enterprise remittances)	.80
5.	— Net interest originating in rest of world	−1.39
6.	+ Services of consumer durables (our imputation)	6.39
7.	— Taxes not related to factor outlay	7.55
8.	+ Subsidies	.76
9.	+ Capital assistance subsidies	.12
10.	— Residual error of estimate	— .35
11.	= Gross private domestic product	74.08
	Factor Outlay	
1.	National income	64.24
2.	+ Capital consumption allowances	9.81
3.	+ Services of consumer durables (our imputation)	6.39
4.	— GNP originating in general government (2 + 3 + 4 above)	13.05
5.	+ Capital assistance subsidies	.12
6.	+ Indirect taxes related to factor outlay	4.50
7.	— GNP originating in rest of world	−1.39
8.	— Twice the residual error of estimate	— .69
9.	= Gross private domestic factor outlay	74.08

Table 11.A.2C Private Domestic Capital Input, 1947–73
Canada

Year	Private Domestic Capital Stock: Price Index (1)	Private Domestic Capital Stock: Quantity Index (2)	Rate of Return to Capital in the Business Sector: Nominal Rate (3)	Rate of Return to Capital in the Business Sector: Own Rate (4)	Services per Unit of Stock (5)	Private Domestic Capital Input: Price Index (6)	Private Domestic Capital Input: Quantity Index (7)
1947	.550	69.86	.164	.057	.098	.641	6.42
1948	.635	73.38	.217	.068	.101	.748	7.04
1949	.663	77.25	.114	.072	.103	.805	7.56
1950	.700	82.26	.125	.070	.105	.873	8.12
1951	.800	86.93	.199	.058	.107	.908	8.82
1952	.823	91.29	.103	.073	.109	1.018	9.49
1953	.836	96.60	.082	.066	.111	1.000	10.14
1954	.836	100.31	.054	.053	.113	.907	10.92
1955	.858	105.51	.098	.066	.114	1.044	11.47
1956	.902	112.46	.136	.075	.116	1.072	12.23
1957	.934	118.30	.090	.059	.118	.981	13.26
1958	.950	123.00	.079	.061	.120	.999	14.15
1959	.969	128.08	.081	.060	.121	1.020	14.86
1960	.989	132.66	.076	.055	.122	1.021	15.59
1961	1.000	136.49	.063	.050	.123	1.000	16.27
1962	1.017	141.10	.077	.055	.124	1.023	16.87
1963	1.049	146.13	.096	.060	.125	1.092	17.57
1964	1.090	152.27	.108	.064	.126	1.173	18.38
1965	1.152	159.89	.130	.067	.127	1.214	19.39
1966	1.224	168.12	.134	.066	.129	1.250	20.69
1967	1.281	174.79	.096	.053	.132	1.168	22.15
1968	1.309	181.57	.075	.054	.134	1.194	23.36
1969	1.373	189.29	.097	.046	.135	1.235	24.53
1970	1.431	195.13	.098	.049	.136	1.246	25.81
1971	1.506	202.00	.101	.047	.137	1.351	26.78
1972	1.602	209.98	.099	.045	.139	1.366	27.99
1973	1.740	219.94	.167	.065	.140	1.700	29.47

Table 11.A.3C Private Domestic Labor Input, 1947–73
Canada

Year	Private Domestic Persons Engaged (1)	Private Domestic Hours per Person (2)	Index of Educational Attainment (3)	Private Domestic Labor Input	
				Price Index (4)	Quantity Index (5)
1947	4.479	1.100	.923	.440	17.71
1948	4.519	1.100	.928	.487	17.94
1949	4.611	1.091	.932	.507	18.24
1950	4.586	1.071	.936	.564	17.89
1951	4.694	1.062	.941	.643	18.26
1952	4.742	1.057	.947	.693	18.46
1953	4.785	1.055	.952	.730	18.71
1954	4.750	1.052	.958	.741	18.62
1955	4.843	1.043	.964	.775	18.94
1956	5.036	1.040	.970	.833	19.77
1957	5.136	1.028	.976	.885	20.04
1958	5.060	1.021	.982	.909	19.74
1959	5.198	1.018	.988	.931	20.36
1960	5.251	1.012	.994	.969	20.55
1961	5.172	1.000	1.000	1.000	20.13
1962	5.297	1.000	1.005	1.026	20.71
1963	5.405	.992	1.010	1.068	21.07
1964	5.585	.986	1.015	1.119	21.74
1965	5.789	.978	1.019	1.198	22.45
1966	5.987	.967	1.024	1.305	23.06
1967	6.103	.961	1.029	1.402	23.50
1968	6.154	.950	1.034	1.495	23.54
1969	6.305	.941	1.039	1.630	24.00
1970	6.334	.932	1.044	1.749	23.97
1971	6.465	.926	1.049	1.875	24.44
1972	6.652	.921	1.054	2.016	25.12
1973	6.986	.921	1.059	2.130	26.51

Table 11.A.4C **Gross Private Domestic Product and Factor Input, 1947–73**
Canada
(constant dollars of 1961)

Year	Gross Private Domestic Product		Relative Share of Investment Goods Product	Private Domestic Factor Input		Relative Share of Property Compensation
	Price Index (1)	Quantity Index (2)	(3)	Price Index (4)	Quantity Index (5)	(6)
1947	.652	18.26	.275	.519	22.92	.346
1948	.740	18.91	.294	.586	23.89	.376
1949	.768	19.97	.300	.618	24.82	.397
1950	.781	22.01	.307	.681	25.24	.413
1951	.863	22.89	.294	.748	26.43	.406
1952	.897	25.04	.297	.819	27.43	.430
1953	.897	26.55	.299	.837	28.44	.426
1954	.898	26.40	.296	.810	29.26	.418
1955	.926	28.80	.302	.883	30.18	.449
1956	.934	31.68	.327	.830	31.80	.443
1957	.945	32.54	.332	.827	33.18	.423
1958	.961	33.37	.313	.948	33.84	.441
1959	.980	34.81	.306	.970	35.18	.444
1960	1.000	35.84	.897	.992	36.13	.444
1961	1.000	36.40	.292	1.000	36.40	.447
1962	.996	38.65	.300	1.024	37.58	.448
1963	1.021	40.82	.309	1.079	38.64	.460
1964	1.049	43.76	.313	1.144	40.12	.470
1965	1.073	46.99	.326	1.205	41.86	.467
1966	1.115	50.20	.336	1.279	43.76	.462
1967	1.138	51.68	.329	1.290	45.59	.440
1968	1.157	54.51	.330	1.350	46.72	.442
1969	1.220	56.89	.324	1.439	48.25	.436
1970	1.254	59.07	.324	1.502	49.31	.434
1971	1.321	62.11	.321	1.619	50.66	.441
1972	1.361	65.32	.323	1.695	52.45	.430
1973	1.528	69.74	.323	1.927	55.29	.470

Table 11.A.1F Gross Private Domestic Product and Factor Outlay, 1970

France

(billions of francs)

	Product	
1.	Gross national product	808.44
2.	— Inventory valuation adjustment (our estimate)	—.29
3.	— Wages and salaries in general government	72.17
4.	— Capital consumption allowances in general government	1.46
5.	— Income originating in rest of world	1.02
6.	+ Services of consumer durables (our imputation)	42.92
7.	+ Services of durables held by institutions (our imputation)	.26
8.	+ Net rent on institutional real estate (our imputation)	.47
9.	— Taxes not related to factor outlay	26.25
10.	+ Production subsidies	16.07
11.	+ Equipment and war damage subsidies	8.95
12.	= Gross private domestic product	706.50
	Factor Outlay	
1.	National income	619.30
2.	— Inventory valuation adjustment (2 above)	—.29
3.	+ Equipment and war damage subsidies (11 above)	8.95
4.	+ Indirect taxes, French definition	120.51
5.	— Indirect taxes, our definition	130.64
6.	+ Capital consumption allowances	84.69
7.	+ Services of consumer durables (6 above)	42.92
8.	+ Services of durables held by institutions (7 above)	.26
9.	+ Net rent on institutional real estate (8 above)	.47
10.	— GNP originating in general government (3 + 4 above)	73.63
11.	— GNP originating in rest of world (5 above)	1.02
12.	+ Indirect taxes related to factor outlay	34.39
13.	= Gross private domestic factor outlay	706.50

Table 11.A.2F Private Domestic Capital Input, 1950–73
France

Year	Private Domestic Capital Stock		Rate of Return to Capital in the Business Sector	Services per Unit of Stock (4)	Private Domestic Capital Input	
	Price Index (1)	Quantity Index (2)	Nominal Rate (3)		Price Index (5)	Quantity Index (6)
1950	.440	674.4	.156	.112	.555	71.9
1951	.512	697.8	.228	.113	.535	75.9
1952	.598	717.9	.219	.113	.589	79.2
1953	.607	744.1	.084	.115	.648	82.3
1954	.618	774.0	.084	.116	.643	86.0
1955	.636	806.4	.094	.117	.652	90.2
1956	.669	842.3	.110	.118	.661	95.0
1957	.723	877.6	.141	.119	.705	100.3
1958	.785	909.7	.131	.120	.712	105.6
1959	.833	940.9	.107	.121	.767	110.5
1960	.859	983.9	.101	.122	.879	115.2
1961	.895	1029.3	.108	.124	.904	121.6
1962	.938	1079.6	.115	.125	.942	129.1
1963	1.000	1132.4	.126	.127	1.000	137.6
1964	1.052	1195.7	.119	.130	1.060	147.0
1965	1.094	1256.1	.107	.132	1.083	157.7
1966	1.133	1324.6	.122	.133	1.197	167.6
1967	1.176	1392.1	.125	.135	1.233	178.6
1968	1.226	1462.9	.125	.136	1.262	189.7
1969	1.313	1551.7	.160	.138	1.373	201.3
1970	1.399	1642.5	.156	.139	1.453	215.3
1971	1.480	1730.1	.139	.140	1.470	229.6
1972	1.562	1824.9	.140	.141	1.573	244.4
1973	1.674	1931.1	.156	.143	1.693	260.7

Table 11.A.3F Private Domestic Labor Input, 1950–73
France

Year	Private Domestic Persons Engaged (1)	Private Domestic Hours per Person (2)	Index of Educational Attainment (3)	Private Domestic Labor Input	
				Price Index (4)	Quantity Index (5)
1950	17.613	1.010	.937	.246	207.4
1951	17.688	1.017	.942	.306	210.7
1952	17.616	1.010	.947	.370	209.6
1953	17.443	1.008	.952	.390	208.1
1954	17.458	1.011	.957	.419	210.1
1955	17.433	1.010	.962	.453	210.7
1956	17.402	1.012	.966	.500	211.7
1957	17.460	1.013	.971	.548	213.8
1958	17.395	1.004	.976	.629	212.2
1959	17.247	1.002	.982	.695	211.1
1960	17.260	1.011	.987	.742	214.2
1961	17.233	1.011	.992	.817	214.9
1962	17.301	1.010	.996	.901	216.5
1963	17.531	1.000	1.000	1.000	218.1
1964	17.779	.995	1.004	1.084	221.0
1965	17.818	.983	1.008	1.173	219.7
1966	17.888	.987	1.013	1.188	222.5
1967	17.898	.981	1.017	1.283	222.1
1968	17.820	.974	1.021	1.430	220.6
1969	18.092	.972	1.025	1.564	224.4
1970	18.318	.963	1.030	1.741	226.1
1971	18.375	.955	1.034	1.944	225.7
1972	18.449	.944	1.038	2.181	225.0
1973	18.666	.935	1.043	2.488	226.6

Table 11.A.4F Gross Private Domestic Product and Factor Input, 1950–73
France
(constant francs of 1963)

Year	Gross Private Domestic Product		Private Domestic Factor Input	
	Price Index (1)	Quantity Index (2)	Price Index (3)	Quantity Index (4)
1950	.498	182.6	.338	269.2
1951	.561	187.2	.378	277.9
1952	.643	193.1	.441	281.4
1953	.643	209.2	.473	284.4
1954	.652	219.9	.492	291.0
1955	.666	231.8	.520	296.9
1956	.695	242.7	.555	303.6
1957	.731	257.2	.602	311.8
1958	.799	261.1	.660	316.3
1959	.843	274.6	.723	320.4
1960	.871	298.6	.792	328.5
1961	.906	315.0	.849	336.1
1962	.943	335.7	.916	345.4
1963	1.000	355.8	1.000	355.8
1964	1.030	384.1	1.075	367.9
1965	1.057	405.5	1.137	377.0
1966	1.082	429.5	1.194	389.5
1967	1.119	451.5	1.263	400.0
1968	1.176	471.7	1.356	409.0
1969	1.227	511.3	1.480	423.8
1970	1.300	543.6	1.611	438.5
1971	1.363	569.6	1.723	450.6
1972	1.455	601.4	1.894	462.2
1973	1.563	642.8	2.105	477.3

Table 11.A.1G Gross Private Domestic Product and Factor Outlay, 1970
Germany
(billions of DM)

	Product	
1.	Gross national product	685.6
2.	— Labor compensation, government sector	59.3
3.	— Government contribution to legal accident insurance	2.0
4.	— Capital consumption, government	3.7
5.	= Private gross national product	622.4
6.	+ Services of consumers' durables (our imputation)	41.9
7.	— Rest of world gross national product	—1.4
8.	— Indirect taxes	89.1
9.	+ Subsidies	9.5
10.	+ Contribution to legal accident insurance, business and nonprofit institutions	4.1
11.	+ Business tax	12.1
12.	+ Real estate tax + fire protection tax (see 11)	2.8
13.	+ Motor vehicle tax (see 11)	3.8
14.	— Motor vehicle tax, private households	2.1
15.	= Gross private domestic product	606.7

	Factor Outlay	
1.	Capital consumption allowances, business and nonprofit institutions	71.1
2.	+ Services of consumer durables (our imputation)	41.9
3.	+ Indirect tax on property (11 above + 12 + 13 — 14)	16.6
4.	+ Income originating in business, households, and nonprofit institutions	473.0
5.	+ Contribution to legal accident insurance, business and nonprofit institutions (10 above)	4.1
6.	= Gross private domestic factor outlay	606.7

Table 11.A.2G Private Domestic Capital Input, 1950–73
Germany
(billions of DM)

Year	Private Domestic Capital Stock		Rate of Return to Capital in the Business Sector	Services per Unit of Stock (4)	Private Domestic Capital Input	
	Price Index (1)	Quantity Index (2)	Nominal Rate (3)		Price Index (5)	Quantity Index (6)
1950	.724	402.4	.046	.132	.593	50.1
1951	.805	426.9	.111	.130	.710	52.3
1952	.839	455.9	.078	.129	.809	55.1
1953	.823	486.4	.043	.130	.796	59.1
1954	.814	522.3	.049	.130	.798	63.3
1955	.831	568.6	.076	.131	.885	68.2
1956	.843	615.4	.069	.131	.895	74.5
1957	.864	663.9	.074	.131	.920	80.7
1958	.882	712.9	.067	.131	.905	87.2
1959	.895	765.7	.070	.132	.965	93.8
1960	.923	829.6	.082	.131	1.035	100.4
1961	.958	895.8	.079	.131	1.028	109.1
1962	1.000	963.5	.075	.132	1.000	118.0
1963	1.032	1026.6	.070	.133	1.006	127.8
1964	1.051	1103.3	.066	.133	1.064	136.7
1965	1.094	1188.4	.081	.134	1.095	147.7
1966	1.120	1263.2	.067	.135	1.074	160.5
1967	1.114	1318.0	.043	.136	1.022	171.5
1968	1.120	1390.7	.061	.136	1.131	178.7
1969	1.162	1482.5	.078	.136	1.182	188.8
1970	1.278	1584.1	.119	.137	1.236	202.7
1971	1.358	1685.5	.090	.138	1.241	218.8
1972	1.418	1786.9	.080	.140	1.280	235.2
1973	1.477	1888.7	.077	.140	1.323	250.3

Table 11.A.3G Private Domestic Labor Input, 1950–73

Germany
(billions of DM)

Year	Private Domestic Persons Engaged (1)	Private Domestic Hours per Person (2)	Index of Educational Attainment (3)	Private Domestic Labor Input	
				Price Index (4)	Quantity Index (5)
1950	19.4	1.146	.991	.344	168.4
1951	19.9	1.138	.992	.402	173.4
1952	20.3	1.136	.992	.432	177.3
1953	20.8	1.131	.993	.458	182.5
1954	21.4	1.132	.994	.480	188.9
1955	22.3	1.129	.994	.519	197.3
1956	22.9	1.112	.995	.570	200.3
1957	23.3	1.076	.996	.632	197.5
1958	23.5	1.057	.997	.688	195.8
1959	23.6	1.039	.998	.738	194.5
1960	24.0	1.030	.999	.806	196.9
1961	24.2	1.017	.999	.895	196.8
1962	24.2	1.000	1.000	1.000	193.7
1963	24.2	.981	1.001	1.078	190.6
1964	24.1	.995	1.001	1.154	193.0
1965	24.1	.979	1.002	1.270	191.3
1966	24.0	.967	1.003	1.378	187.8
1967	23.0	.950	1.004	1.455	177.2
1968	23.0	.963	1.005	1.530	180.5
1969	23.4	.958	1.007	1.671	183.5
1970	23.6	.950	1.008	1.930	184.5
1971	23.5	.929	1.009	2.204	180.6
1972	23.4	.919	1.010	2.442	177.8
1973	23.3	.915	1.012	2.760	177.2

Table 11.A.4G Gross Private Domestic Product and Factor Input, 1950–73
Germany
(constant DM of 1962)

Year	Gross Private Domestic Product		Private Domestic Factor Input	
	Price Index (1)	Quantity Index (2)	Price Index (3)	Quantity Index (4)
1950	.704	124.4	.423	207.1
1951	.779	137.3	.499	214.4
1952	.813	149.1	.547	221.5
1953	.805	162.3	.564	231.4
1954	.804	175.6	.582	242.5
1955	.821	198.2	.636	256.2
1956	.842	214.9	.677	267.2
1957	.868	229.5	.730	272.8
1958	.894	239.0	.765	279.2
1959	.908	257.8	.819	285.8
1960	.926	283.5	.888	295.7
1961	.963	299.5	.944	305.4
1962	1.000	311.8	1.000	311.8
1963	1.028	325.0	1.050	318.2
1964	1.054	349.2	1.118	329.0
1965	1.088	371.9	1.199	337.6
1966	1.119	385.3	1.249	345.1
1967	1.124	385.4	1.265	342.3
1968	1.148	416.8	1.359	352.0
1969	1.185	447.2	1.456	363.7
1970	1.264	479.9	1.614	375.9
1971	1.352	495.0	1.748	382.9
1972	1.421	517.2	1.881	390.7
1973	1.493	549.5	2.051	400.1

Table 11.A.1I Gross Private Domestic Product and Factor Outlay, 1970

Italy

(trillions of lire)

	Product	
1.	Gross national product	58.26
2.	— Wages and salaries in general government	5.26
3.	— Capital consumption allowances and property income of general government	.36
4.	— Rest of world gross national product	.32
5.	+ Services of consumer durables (our imputation)	4.00
6.	— Taxes not related to factor outlay	5.94
7.	+ Subsidies	.90
8.	= Gross private domestic product	51.29
	Factor Outlay	
1.	National income, gross of capital consumption allowances	52.21
2.	+ Services of consumer durables (our imputation)	4.00
3.	— GNP originating in general government (2 + 3 above)	5.62
4.	— Direct taxes per the national accounts	3.56
5.	+ Direct taxes (our estimate)	3.08
6.	+ Indirect taxes (our estimate)	7.43
7.	— Taxes not related to factor outlay	5.94
8.	— GNP originating in rest of world	.32
9.	= Gross private domestic factor outlay	51.29

Table 11.A.2I Private Domestic Capital Input, 1952–73
Italy

Year	Private Domestic Capital Stock: Price Index (1)	Private Domestic Capital Stock: Quantity Index (2)	Rate of Return to Capital in the Business Sector: Nominal Rate (3)	Services per Unit of Stock (4)	Private Domestic Capital Input: Price Index (5)	Private Domestic Capital Input: Quantity Index (6)
1952	.802	50.35	.061	.134	.629	6.66
1953	.802	51.47	.056	.135	.688	6.79
1954	.805	52.68	.045	.135	.665	6.97
1955	.815	54.51	.073	.136	.727	7.16
1956	.833	56.52	.082	.136	.755	7.41
1957	.858	58.74	.094	.136	.786	7.70
1958	.860	60.95	.068	.136	.813	8.01
1959	.857	63.54	.064	.136	.844	8.31
1960	.873	66.89	.095	.136	.888	8.67
1961	.892	71.03	.109	.137	.956	9.15
1962	.935	75.65	.126	.138	1.005	9.78
1963	1.000	80.81	.144	.139	1.000	10.49
1964	1.073	84.79	.126	.140	.993	11.33
1965	1.091	88.10	.090	.140	1.006	11.91
1966	1.108	91.60	.097	.140	1.087	12.34
1967	1.136	96.06	.103	.140	1.138	12.83
1968	1.163	100.59	.102	.141	1.171	13.51
1969	1.238	105.92	.151	.141	1.293	14.18
1970	1.383	111.82	.186	.141	1.283	14.95
1971	1.468	116.65	.113	.142	1.136	15.87
1972	1.544	121.39	.094	.143	1.182	16.67
1973	1.791	127.17	.196	.144	1.356	17.46

Table 11.A.3I Private Domestic Labor Input, 1952–73

Italy

Year	Private Domestic Persons Engaged (1)	Private Domestic Hours per Person (2)	Index of Educational Attainment (3)	Private Domestic Labor Input	
				Price Index (4)	Quantity Index (5)
1952	15.343	.920	.946	.399	14.58
1953	15.661	.938	.948	.429	15.05
1954	16.044	.959	.951	.455	15.64
1955	16.096	.959	.953	.495	15.62
1956	16.241	.955	.956	.541	15.61
1957	16.410	.968	.958	.570	15.90
1958	16.565	.967	.960	.608	15.94
1959	16.497	.975	.963	.634	16.09
1960	16.677	1.004	.965	.672	16.53
1961	16.808	1.001	.977	.731	16.67
1962	16.761	.982	.988	.849	16.32
1963	16.667	1.000	1.000	1.000	16.47
1964	16.654	.958	1.013	1.157	15.91
1965	16.262	.903	1.026	1.289	14.85
1966	16.048	.934	1.040	1.340	15.26
1967	16.281	.943	1.053	1.448	15.78
1968	16.299	.947	1.067	1.543	15.99
1969	16.440	.915	1.081	1.723	15.68
1970	16.536	.921	1.095	2.009	15.98
1971	16.496	.890	1.110	2.329	15.58
1972	16.334	.870	1.124	2.621	15.18
1973	16.507	.849	1.139	3.200	15.11

Table 11.A.4I Gross Private Domestic Product and Factor Input, 1952–73
Italy
(constant lire of 1963)

Year	Gross Private Domestic Product		Private Domestic Factor Input	
	Price Index (1)	Quantity Index (2)	Price Index (3)	Quantity Index (4)
1952	.728	13.73	.480	20.85
1953	.742	14.99	.520	21.41
1954	.756	15.54	.531	22.14
1955	.767	16.87	.578	22.36
1956	.794	17.69	.619	22.66
1957	.817	18.51	.650	23.26
1958	.827	19.58	.684	23.67
1959	.824	20.89	.713	24.16
1960	.844	22.27	.753	24.98
1961	.864	24.22	.815	25.68
1962	.921	25.72	.909	26.07
1963	1.000	26.96	1.000	26.96
1964	1.064	27.89	1.091	27.19
1965	1.079	28.85	1.172	26.55
1966	1.110	30.50	1.237	27.37
1967	1.142	32.81	1.320	28.37
1968	1.169	34.66	1.388	29.18
1969	1.231	36.83	1.543	29.40
1970	1.321	38.82	1.689	30.36
1971	1.437	37.81	1.781	30.50
1972	1.529	38.89	1.952	30.46
1973	1.743	41.32	2.336	30.84

Table 11.A.1J Gross Private Domestic Product and Factor Outlay, 1970

Japan

(trillions of yen)

	Product	
1.	Gross national product	70.73
2.	— Net factor income from abroad	—.16
3.	+ Services of consumer durables	2.41
4.	— Compensation of employees by public administration (general government)	2.16
5.	— Rent, interest, and dividends by general government	.60
6.	+ Interest and dividends by general government	.42
7.	= Gross private domestic product before sales tax	70.96
8.	— Indirect taxes	5.31
9.	+ Monopoly profit	.27
10.	+ Current subsidies	.77
11.	+ Business tax (corporate + noncorporate)	.92
12.	+ Real estate acquisition tax	.09
13.	+ Motor vehicle tax (prefectural + municipal)	.19
14.	+ Mine-lot tax	.00
15.	+ Fixed estate tax (prefectural + municipal)	.52
16.	= Gross private domestic product	68.41
	Factor Outlay	
1.	Provisions for the consumption of fixed capital	9.49
2.	+ Statistical discrepancy	—.21
3.	+ Compensation of employees	31.02
4.	— Compensation of employees by public administration	2.16
5.	+ Income from unincorporated enterprises	11.16
6.	+ Income from property, rent	2.56
7.	+ Income from property, interest	3.29
8.	— Interest on consumers' debt	.24
9.	— Interest on public debt	.42
10.	+ Income from property, dividends	.80
11.	+ Corporate transfers to households and nonprofit institutions	.10
12.	+ Direct taxes and charges on private corporations	3.22
13.	+ Saving of private corporations	4.71
14.	+ Profit from government enterprises	.09
15.	+ Monopoly profit	.27
16.	— Net factor income from abroad	—.16
17.	+ Services from consumer durables	2.41
18.	+ Interest and dividends by general government	.42
19.	+ Certain indirect taxes (above, 11 + 12 + 13 + 14 + 15)	1.72
20.	= Gross private domestic factor outlay	68.41

Table 11.A.2J Private Domestic Capital Input, 1952–73
Japan
(trillions of yen)

Year	Private Domestic Capital Stock		Rate of Return to Capital in the Business Sector	Services per Unit of Stock (4)	Private Domestic Capital Input	
	Price Index (1)	Quantity Index (2)	Nominal Rate (3)		Price Index (5)	Quantity Index (6)
1952	.439	45.96	.102	.145	.349	6.55
1953	.468	46.89	.091	.144	.338	6.64
1954	.483	47.67	.066	.141	.372	6.62
1955	.497	48.90	.085	.141	.400	6.73
1956	.560	51.02	.193	.140	.465	6.84
1957	.611	54.17	.150	.145	.507	7.40
1958	.624	56.13	.067	.154	.446	8.33
1959	.652	58.71	.097	.157	.496	8.79
1960	.683	62.76	.121	.160	.603	9.42
1961	.723	69.39	.152	.167	.744	10.51
1962	.736	74.64	.093	.177	.653	12.29
1963	.747	80.74	.098	.184	.667	13.76
1964	.764	88.25	.129	.186	.771	15.05
1965	.781	94.44	.115	.192	.725	16.91
1966	.815	101.37	.147	.196	.795	18.48
1967	.859	111.47	.180	.198	.902	20.08
1968	.904	123.92	.199	.203	.977	22.58
1969	.949	137.68	.190	.210	.980	25.98
1970	1.000	154.29	.190	.217	1.000	29.84
1971	1.019	169.55	.126	.224	.905	34.58
1972	1.075	185.02	.157	.231	.909	39.10
1973	1.282	203.67	.291	.237	.980	43.86

Table 11.A.3J Private Domestic Labor Input, 1952–73

Japan

(trillions of yen)

Year	Private Domestic Persons Engaged (1)	Private Domestic Hours per Person (2)	Index of Educational Attainment (3)	Private Domestic Labor Input	
				Price Index (4)	Quantity Index (5)
1952	22.72	1.026	.936	.183	20.23
1953	23.65	1.036	.935	.210	21.25
1954	24.20	1.031	.943	.224	21.83
1955	25.32	1.038	.932	.234	22.73
1956	26.61	1.062	.936	.240	24.54
1957	28.02	1.056	.938	.257	25.76
1958	29.08	1.055	.937	.264	26.67
1959	29.91	1.066	.944	.275	27.92
1960	31.15	1.080	.949	.298	29.61
1961	31.78	1.071	.950	.342	29.98
1962	33.02	1.054	.950	.391	30.65
1963	33.93	1.047	.955	.441	31.47
1964	34.91	1.043	.960	.490	32.43
1965	36.81	1.028	.964	.539	33.84
1966	37.68	1.029	.966	.596	34.76
1967	38.92	1.028	.973	.662	36.11
1968	40.02	1.027	.981	.745	37.38
1969	40.69	1.012	.992	.851	37.91
1970	41.59	1.000	1.000	1.000	38.58
1971	42.24	.989	1.007	1.158	39.03
1972	42.80	.984	1.014	1.316	39.59
1973	44.25	.975	1.022	1.605	40.92

Table 11.A.4J Gross Private Domestic Product and Factor Input, 1952–73
Japan
(constant yen of 1970)

Year	Gross Private Domestic Product		Private Domestic Factor Input	
	Price Index (1)	Quantity Index (2)	Price Index (3)	Quantity Index (4)
1952	.533	11.21	.241	24.77
1953	.544	12.32	.261	25.69
1954	.560	13.13	.281	26.13
1955	.550	14.56	.297	26.98
1956	.597	15.19	.318	28.55
1957	.619	16.74	.342	30.28
1958	.600	17.93	.333	32.30
1959	.627	19.20	.355	33.90
1960	.676	21.48	.402	36.10
1961	.704	25.65	.475	38.04
1962	.701	28.53	.486	41.14
1963	.725	31.81	.528	43.72
1964	.768	35.83	.596	46.16
1965	.774	39.41	.614	49.66
1966	.832	42.54	.676	52.33
1967	.881	47.67	.758	55.41
1968	.924	54.01	.840	59.46
1969	.955	60.47	.905	63.75
1970	1.000	68.41	1.000	68.41
1971	1.019	75.07	1.044	73.31
1972	1.074	81.63	1.128	77.72
1973	1.228	88.49	1.309	83.01

Table 11.A.1K Gross Private Domestic Product and Factor Outlay, 1970

Korea

(billions of won)

	Product	
1.	Gross national product	2,589.3
2.	— Wages and salaries in general government	186.9
3.	— Capital consumption allowances in general government	4.8
4.	— General government income from property	58.8
5.	— Rest of world gross national product	11.9
6.	+ Services of consumer durables	89.4
7.	— Taxes not related to factor outlay	197.8
8.	+ Subsidies	0.7
9.	— Statistical discrepancy	−32.2
10.	= Gross private domestic product	2,251.5
	Factor Outlay	
1.	National income	2,177.7
2.	+ Capital consumption allowances	160.2
3.	+ Services of consumer durables (our imputation)	89.4
4.	— GNP originating in general government (2 + 3 + 4 above)	250.4
5.	— Direct taxes on corporations per the national accounts	42.7
6.	+ Direct taxes on corporations (our estimate)	72.5
7.	— Direct taxes on households per the national accounts	98.9
8.	+ Direct taxes on households (our estimate)	86.0
9.	+ Indirect taxes	235.3
10.	— Taxes not related to factor outlay	197.8
11.	— GNP originating in rest of world	11.9
12.	— Statistical discrepancy	−32.2
13.	= Gross private domestic factor outlay	2,251.5

Table 11.A.2K Private Domestic Capital Input, 1960–73
Korea

Year	Private Domestic Capital Stock: Price Index (1)	Private Domestic Capital Stock: Quantity Index (2)	Rate of Return to Capital in the Business Sector: Nominal Rate (3)	Services per Unit of Stock (4)	Private Domestic Capital Input: Price Index (5)	Private Domestic Capital Input: Quantity Index (6)
1960	.174	4971.0	.152	.087	.159	433.7
1961	.203	5010.8	.306	.088	.237	436.1
1962	.231	5057.9	.239	.088	.267	442.0
1963	.266	5260.9	.312	.090	.381	453.8
1964	.346	5409.4	.407	.090	.564	472.0
1965	.413	5548.6	.267	.091	.580	489.6
1966	.498	5848.8	.273	.091	.689	505.0
1967	.572	6183.4	.203	.094	.651	551.7
1968	.678	6591.1	.227	.100	.750	618.0
1969	.868	7069.2	.243	.107	.843	704.9
1970	1.000	7483.0	.237	.113	1.000	800.2
1971	1.173	7894.2	.222	.118	1.033	880.9
1972	1.329	8192.4	.235	.122	1.234	964.3
1973	1.541	8709.9	.269	.124	1.613	1018.3

Table 11.A.3K Private Domestic Labor Input, 1960–73
Korea

Year	Private Domestic Persons Engaged (1)	Private Domestic Hours per Person (2)	Index of Educational Attainment (3)	Private Domestic Labor Input: Price Index (4)	Private Domestic Labor Input: Quantity Index (5)
1960	6.785	.982	.887	.155	920.2
1961	6.975	1.003	.898	.163	977.9
1962	7.170	.982	.909	.190	996.4
1963	7.374	.982	.920	.249	1038.0
1964	7.504	.952	.931	.352	1036.0
1965	7.891	.994	.943	.378	1151.5
1966	8.093	.987	.954	.472	1186.7
1967	8.361	1.000	.965	.598	1256.8
1968	8.772	1.019	.977	.662	1359.9
1969	9.021	1.043	.988	.822	1448.5
1970	9.317	1.000	1.000	1.000	1451.3
1971	9.604	1.024	1.012	1.135	1550.5
1972	10.081	1.029	1.024	1.312	1653.5
1973	10.644	1.029	1.036	1.530	1766.6

Table 11.A.4K Gross Private Domestic Product and Factor Input, 1960–73
Korea
(constant won of 1970)

Year	Gross Private Domestic Product		Private Domestic Factor Input	
	Price Index (1)	Quantity Index (2)	Price Index (3)	Quantity Index (4)
1960	.228	925.8	.155	1358.0
1961	.270	975.2	.186	1414.8
1962	.306	1004.0	.213	1438.6
1963	.389	1106.5	.289	1490.2
1964	.535	1178.3	.417	1512.8
1965	.568	1265.2	.440	1634.6
1966	.635	1430.9	.539	1685.1
1967	.713	1556.1	.615	1804.4
1968	.778	1751.2	.690	1975.0
1969	.854	2090.4	.829	2152.6
1970	1.000	2251.5	1.000	2251.5
1971	1.087	2456.0	1.098	2430.6
1972	1.252	2683.6	1.284	2615.7
1973	1.346	3249.5	1.562	2782.7

Table 11.A.1N Gross Private Domestic Product and Factor Outlay, 1970
Netherlands
(billions of guilders)

	Product
1.	Gross national product 114.98
2.	— Wages and salaries in general government 13.48
3.	— Capital consumption allowances in general government .80
4.	— Taxes paid by government .04
5.	— GNP originating in rest of world .41
6.	+ Service of consumer durables (our imputation) 13.58
7.	— Taxes not related to factor outlay 11.09
8.	+ Subsidies 1.52
9.	= Gross private domestic product 104.26

	Factor Outlay
1.	National income 93.70
2.	+ Capital consumption allowances 9.73
3.	+ Services of consumer durables (our imputation) 13.58
4.	— National income originating in general government (2 + 3) 14.28
5.	— Indirect taxes considered direct by Netherlands national accounts .71
6.	+ Indirect taxes related to factor outlay 1.94
7.	— GNP originating in rest of world (5 above) .41
8.	= Gross private domestic factor outlay 104.26

Table 11.A.2N Private Domestic Capital Input, 1951–73
Netherlands

Year	Private Domestic Capital Stock: Price Index (1)	Private Domestic Capital Stock: Quantity Index (2)	Rate of Return to Capital in the Business Sector: Nominal Rate (3)	Services per Unit of Stock (4)	Private Domestic Capital Input: Price Index (5)	Private Domestic Capital Input: Quantity Index (6)
1951	.620	124.21	.199	.098	.796	11.77
1952	.666	125.15	.121	.097	.827	12.08
1953	.656	127.22	.042	.097	.827	12.13
1954	.697	132.15	.135	.097	.910	12.39
1955	.728	137.68	.115	.099	1.011	13.05
1956	.777	144.15	.137	.100	1.047	13.79
1957	.826	150.81	.127	.102	1.034	14.71
1958	.840	154.73	.071	.104	.947	15.65
1959	.842	159.63	.067	.105	.972	16.20
1960	.862	166.86	.091	.106	1.054	16.89
1961	.881	174.39	.081	.108	1.013	17.95
1962	.935	181.49	.124	.111	1.001	19.28
1963	1.000	188.11	.127	.114	1.000	20.73
1964	1.055	198.01	.113	.117	1.079	22.09
1965	1.109	207.95	.108	.120	1.126	23.75
1966	1.164	217.72	.096	.123	1.089	25.58
1967	1.179	228.01	.064	.125	1.131	27.20
1968	1.221	239.11	.087	.126	1.218	28.80
1969	1.287	251.19	.104	.128	1.279	30.56
1970	1.361	265.83	.109	.129	1.327	32.45
1971	1.496	278.86	.143	.132	1.392	35.02
1972	1.636	290.99	.144	.134	1.493	37.45
1973	1.779	304.25	.133	.137	1.550	39.83

Table 11.A.3N Private Domestic Labor Input, 1951–73

Netherlands

Year	Private Domestic Persons Engaged (1)	Private Domestic Hours per Person (2)	Index of Educational Attainment (3)	Private Domestic Labor Input	
				Price Index (4)	Quantity Index (5)
1951	3.411	1.041	.942	.451	23.06
1952	3.367	1.043	.946	.473	22.92
1953	3.417	1.047	.951	.489	23.48
1954	3.483	1.047	.956	.530	24.05
1955	3.547	1.047	.961	.573	24.61
1956	3.602	1.047	.966	.619	25.12
1957	3.619	1.043	.970	.683	25.26
1958	3.580	1.043	.975	.711	25.11
1959	3.620	1.047	.980	.723	25.63
1960	3.692	1.047	.985	.780	26.27
1961	3.746	.998	.990	.876	25.52
1962	3.825	.998	.995	.926	26.19
1963	3.878	1.000	1.000	1.000	26.75
1964	3.952	.989	1.005	1.157	27.10
1965	3.986	.989	1.010	1.278	27.47
1966	4.009	.989	1.015	1.408	27.77
1967	3.986	.972	1.020	1.530	27.26
1968	4.021	.972	1.025	1.659	27.64
1969	4.083	.968	1.030	1.903	28.08
1970	4.129	.948	1.036	2.188	27.97
1971	4.140	.940	1.041	2.458	27.93
1972	4.082	.931	1.046	2.807	27.43
1973	4.085	.923	1.051	3.249	27.33

Table 11.A.4N Gross Private Domestic Product and Factor Input, 1951–73
Netherlands
(constant guilders of 1963)

Year	Gross Private Domestic Product		Private Domestic Factor Input	
	Price Index (1)	Quantity Index (2)	Price Index (3)	Quantity Index (4)
1951	.728	27.15	.586	33.76
1952	.756	27.55	.611	34.08
1953	.724	29.71	.622	34.57
1954	.755	31.83	.679	35.37
1955	.799	34.19	.744	36.71
1956	.831	36.08	.787	38.09
1957	.869	37.39	.824	39.39
1958	.922	35.45	.809	40.40
1959	.875	39.17	.826	41.50
1960	.902	42.43	.893	42.87
1961	.923	43.92	.934	43.39
1962	.948	45.93	.958	45.45
1963	1.000	47.47	1.000	47.47
1964	1.056	52.26	1.122	49.16
1965	1.112	55.58	1.210	51.12
1966	1.164	57.53	1.262	53.08
1967	1.199	60.45	1.344	53.90
1968	1.247	64.88	1.454	55.68
1969	1.333	69.40	1.606	57.63
1970	1.405	74.20	1.769	58.95
1971	1.503	78.14	1.932	60.79
1972	1.598	83.16	2.148	61.86
1973	1.721	87.46	2.377	63.33

Table 11.A.1UK Gross Private Domestic Product and Factor Outlay, 1970
United Kingdom
(billions of pounds)

	Product	
1.	Gross national product	51.07
2.	— Wages and salaries in general government	5.88
3.	— Rent from government	1.12
4.	— Gross trading surplus of government	.15
5.	— Net property income from abroad	.53
6.	+ Services of consumer durables	3.81
7.	+ Subsidies	.90
8.	+ Capital transfer payments	.80
9.	— Indirect taxes (our definition)	8.11
10.	+ Indirect taxes related to factor outlay	2.95
11.	— Selective employment tax paid by government	.32
12.	= Gross private domestic product	43.43

	Factor Outlay	
1.	National income	39.02
2.	+ Capital consumption allowances	4.52
3.	+ Services of consumer durables	3.81
4.	— GNP originating in government	7.15
5.	+ Taxes related to factor outlay	2.95
6.	+ Capital transfer payments	.80
7.	— GNP originating in rest of world	.53
8.	= Gross private domestic product	43.43

Table 11.A.2UK Private Domestic Capital Input, 1955–73
United Kingdom

Year	Private Domestic Capital Stock: Price Index (1)	Private Domestic Capital Stock: Quantity Index (2)	Rate of Return to Capital in the Business Sector: Nominal Rate (3)	Services per Unit of Stock (4)	Private Domestic Capital Input: Price Index (5)	Private Domestic Capital Input: Quantity Index (6)
1955	.624	65.51	.071	.129	.770	8.13
1956	.659	67.55	.072	.131	.748	8.57
1957	.683	69.86	.071	.131	.788	8.88
1958	.707	72.11	.067	.132	.796	9.24
1959	.708	75.00	.072	.134	.812	9.65
1960	.716	78.87	.081	.135	.826	10.16
1961	.733	82.47	.081	.136	.845	10.74
1962	.759	85.57	.073	.137	.839	11.28
1963	.772	89.17	.081	.137	.885	11.73
1964	.797	94.13	.089	.138	.907	12.27
1965	.828	98.78	.085	.138	.908	13.03
1966	.854	102.99	.078	.139	.918	13.71
1967	.869	107.42	.079	.139	.949	14.29
1968	.903	112.14	.081	.139	.993	14.91
1969	.936	116.34	.069	.139	.991	15.59
1970	1.000	120.55	.057	.139	1.000	16.12
1971	1.098	124.77	.065	.138	1.130	16.69
1972	1.261	129.26	.066	.140	1.284	17.49
1973	1.480	133.67	.058	.144	1.381	18.56

Table 11.A.3UK Private Domestic Labor Input, 1955–73
United Kingdom

Year	Private Domestic Persons Engaged (1)	Private Domestic Hours per Person (2)	Index of Educational Attainment (3)	Private Domestic Labor Input	
				Price Index (4)	Quantity Index (5)
1955	20.903	1.068	.914	.372	26.91
1956	21.027	1.062	.919	.404	27.06
1957	20.583	1.057	.925	.433	26.53
1958	20.382	1.048	.931	.455	26.20
1959	20.448	1.064	.936	.464	26.85
1960	20.877	1.050	.942	.492	27.22
1961	21.499	1.036	.947	.530	27.84
1962	21.596	1.027	.953	.558	27.88
1963	21.537	1.039	.959	.576	28.28
1964	21.746	1.041	.965	.613	28.79
1965	21.914	1.025	.970	.659	28.74
1966	21.939	1.005	.976	.715	28.37
1967	21.382	1.009	.982	.761	27.94
1968	21.105	1.016	.988	.815	27.93
1969	21.079	1.016	.994	.875	28.07
1970	20.711	1.000	1.000	1.000	27.31
1971	19.832	.984	1.006	1.153	25.89
1972	19.778	.991	1.012	1.260	26.15
1973	20.232	1.000	1.018	1.390	27.16

Table 11.A.4UK Gross Private Domestic Product and Factor Input, 1955–73
United Kingdom
(constant pounds of 1958)

	Gross Private Domestic Product		Private Domestic Factor Input	
Year	Price Index (1)	Quantity Index (2)	Price Index (3)	Quantity Index (4)
1955	.624	26.07	.491	33.11
1956	.650	26.67	.512	33.90
1957	.675	27.36	.545	33.93
1958	.698	27.63	.564	34.18
1959	.702	28.93	.575	35.28
1960	.709	30.75	.601	36.29
1961	.737	32.34	.634	37.59
1962	.762	32.82	.653	38.34
1963	.781	34.13	.679	39.25
1964	.785	36.66	.712	40.39
1965	.819	37.58	.746	41.29
1966	.851	38.63	.787	41.77
1967	.874	39.85	.829	42.04
1968	.907	41.44	.879	42.74
1969	.955	41.86	.917	43.62
1970	1.000	43.43	1.000	43.43
1971	1.083	44.95	1.144	42.57
1972	1.171	47.32	1.270	43.64
1973	1.251	50.65	1.387	45.71

Table 11.A.1US Gross Private Domestic Product and Factor Outlay, 1970
United States
(billions of dollars)

	Product	
1.	Private gross national product	867.7
2.	− Rest of the world gross national product	4.6
3.	+ Services of consumer durables (our imputation)	94.9
4.	+ Services of durables held by institutions (our imputation)	2.3
5.	+ Net rent on institutional real estate (our imputation)	.9
6.	− Federal indirect business tax and nontax accruals	19.3
7.	+ Capital stock tax	—
8.	− State and local indirect business tax and nontax accruals	74.7
9.	+ Business motor vehicle licenses	1.4
10.	+ Business property taxes	36.5
11.	+ Business other taxes	3.4
12.	+ Subsidies less current surplus of federal government enterprises	6.3
13.	+ Subsidies less current surplus of state and local government enterprises	−3.6
14.	= Gross private domestic product	911.2
	Factor Outlay	
1.	Capital consumption allowances	90.8
2.	+ Business transfer payments	4.0
3.	+ Statistical discrepancy	−2.1
4.	+ Services of consumer durables (our imputation)	94.9
5.	+ Services of durables held by institutions (our imputation)	2.3
6.	+ Net rent on institutional real estate (our imputation)	.9
7.	+ Certain indirect business taxes (product account above, lines 8 + 10 + 11 + 12)	41.3
8.	+ Income originating in business	647.4
9.	+ Income originating in households and institutions	31.6
10.	= Gross private domestic factor outlay	911.2

Table 11.A.2US Private Domestic Capital Input, 1947–73
United States

Year	Private Domestic Capital Stock		Rate of Return to Capital in the Business Sector	Services per Unit of Stock (4)	Private Domestic Capital Input	
	Price Index (1)	Quantity Index (2)	Nominal Rate (3)		Price Index (5)	Quantity Index (6)
1947	.439	1408.58	.249	.115	.532	155.28
1948	.473	1481.72	.164	.118	.567	166.09
1949	.469	1528.20	.051	.119	.516	176.87
1950	.491	1615.26	.116	.121	.587	184.49
1951	.532	1689.55	.162	.122	.639	197.33
1952	.540	1741.48	.072	.123	.623	208.19
1953	.544	1795.36	.057	.124	.601	215.95
1954	.547	1842.30	.064	.125	.622	224.58
1955	.560	1921.90	.086	.126	.656	231.91
1956	.588	1988.56	.107	.127	.631	244.29
1957	.610	2041.74	.093	.128	.624	254.81
1958	.618	2073.27	.065	.129	.650	263.59
1959	.633	2132.93	.078	.129	.675	268.28
1960	.645	2185.66	.069	.130	.690	277.49
1961	.656	2227.54	.067	.131	.698	286.19
1962	.671	2288.67	.083	.131	.739	292.76
1963	.684	2357.66	.084	.132	.754	302.93
1964	.700	2434.23	.091	.134	.781	314.86
1965	.720	2531.43	.105	.135	.837	328.71
1966	.746	2637.08	.120	.137	.876	346.66
1967	.776	2722.34	.109	.139	.850	367.06
1968	.813	2815.00	.111	.141	.866	383.57
1969	.862	2909.54	.113	.143	.898	401.77
1970	.905	2976.91	.103	.145	.845	420.54
1971	.954	3059.12	.105	.146	.908	433.69
1972	1.000	3167.73	.107	.147	1.000	449.07
1973	1.069	3293.41	.128	.148	1.097	469.76

Table 11.A.3US Private Domestic Labor Input, 1947–73
United States

Year	Private Domestic Persons Engaged (1)	Private Domestic Hours per Person (2)	Index of Educational Attainment (3)	Private Domestic Labor Input	
				Price Index (4)	Quantity Index (5)
1947	52.66	1.132	.825	.316	436.21
1948	53.64	1.120	.831	.341	445.21
1949	51.92	1.106	.836	.349	428.17
1950	53.54	1.107	.842	.397	444.79
1951	55.72	1.105	.847	.396	465.02
1952	56.21	1.100	.852	.419	469.48
1953	57.21	1.093	.857	.442	477.71
1954	55.59	1.081	.862	.454	461.89
1955	57.05	1.085	.867	.471	478.44
1956	58.37	1.076	.872	.497	488.61
1957	58.37	1.061	.878	.525	484.59
1958	56.62	1.052	.888	.536	471.75
1959	57.99	1.058	.899	.557	491.40
1960	58.64	1.052	.906	.575	498.05
1961	58.32	1.044	.913	.589	495.62
1962	59.41	1.046	.920	.609	509.45
1963	59.87	1.047	.927	.626	517.51
1964	60.99	1.042	.933	.654	528.53
1965	62.80	1.043	.940	.674	548.68
1966	65.13	1.036	.948	.708	570.01
1967	66.19	1.026	.956	.740	578.73
1968	67.64	1.019	.965	.790	592.99
1969	69.53	1.015	.974	.840	612.54
1970	69.18	1.000	.982	.896	605.72
1971	69.07	.998	.991	.946	609.14
1972	71.01	1.000	1.000	1.000	633.00
1973	74.15	.998	1.009	1.066	665.43

Table 11.A.4US Gross Private Domestic Product and Factor Input, 1947–73
United States
(constant dollars of 1958)

Year	Gross Private Domestic Product		Private Domestic Factor Input	
	Price Index (1)	Quantity Index (2)	Price Index (3)	Quantity Index (4)
1947	.543	407.00	.388	568.72
1948	.572	429.40	.417	589.17
1949	.557	432.53	.409	589.03
1950	.571	475.60	.443	612.88
1951	.611	507.89	.480	646.67
1952	.619	526.90	.491	664.52
1953	.618	551.54	.501	681.24
1954	.640	546.30	.516	677.68
1955	.644	586.85	.539	701.09
1956	.661	601.21	.548	724.82
1957	.676	610.95	.564	733.00
1958	.694	611.26	.581	730.85
1959	.702	647.72	.603	754.26
1960	.722	662.00	.620	770.70
1961	.726	677.43	.632	778.09
1962	.735	716.60	.660	798.22
1963	.742	744.75	.676	817.05
1964	.753	785.47	.704	840.53
1965	.773	834.43	.737	874.65
1966	.798	885.64	.773	914.52
1967	.814	909.79	.783	945.24
1968	.841	952.06	.820	976.52
1969	.891	982.31	.863	1014.54
1970	.915	981.43	.875	1026.55
1971	.955	1016.02	.930	1042.80
1972	1.000	1082.07	1.000	1082.07
1973	1.063	1152.28	1.079	1135.16

References

Abramovitz, M. 1956. Resource and output trends in the United States since 1870. *American Economic Review* 46, no. 2 (May): 5–23.

Balassa, B., and Bertrand, T. J. 1970. Growth performance of Eastern European economies and comparable Western European countries. *American Economic Review* 60, no. 2 (May): 314–20.

Bank of Canada. Various dates. *Bank of Canada Review*. Ottawa: Queen's Printer.

Bank of Korea. 1972. *National Income Statistics Yearbook, 1972*. Seoul: Bank of Korea.

———. 1973. *Economic Statistics Yearbook, 1973*. Seoul: Bank of Korea.

Barger, H. 1969. Growth in developed nations. *Review of Economics and Statistics* 51, no. 2 (May): 143–48.

Bergson, A. 1974. Soviet post-war economic development. *Wicksell Lectures 1974*. Stockholm: Almqvist and Wicksell.

Brazell, D. W.; Christensen, L. R.; and Cummings, D. 1975. *Real product, real factor input, and productivity in France, 1951–1973*. Social Systems Research Institute, University of Wisconsin, Discussion Paper no. 7527.

Bureau of the Census. Various dates. *Census of Population*. Washington: U.S. Department of Commerce.

———. Various dates. *Current Population Reports*. Washington: U.S. Department of Commerce.

Bureau of Economic Analysis. 1976. *Fixed nonresidential business and residential capital in the United States, 1925–75*. Washington: U.S. Department of Commerce.

———. Various dates. *The Survey of Current Business*. Washington: U.S. Department of Commerce.

Bureau of Labor Statistics. Various dates. *Special Labor Force Reports*. Washington: U.S. Department of Labor.

Bureau of Statistics. 1975. *Japanese Statistical Yearbook*. Tokyo: Office of the Prime Minister.

Carré, J.; Dubois, P.; and Malinvaud, E. 1972. *La croissance française*. Paris; Editions du Sevil; English tran. by John P. Hatfield, *French economic growth*. Stanford: Stanford University Press (1975).

Centraal Bureau voor de Statistiek. 1967. *Arbeidsvolume in geregistrede arbeidsreserve, 1947–1966*. The Hague: Staatsuitgeverij.

———. *Jaarcijfers voor Nederland*, 1963–64, 1967–68, 1974. The Hague: Staatsuitgeverij.

———. *Maandschrift van het Centraal Bureau voor de Statistiek*, 1954, 1959, 1964, 1967, 1969, 1972, 1973, 1974. The Hague: Staatsuitgeverij.

———. *National rekeningen*, 1956, 1960, 1965, 1972, 1973, 1974. The Hague: Staatsuitgeverij.

Central Statistical Office. 1974. *National Income and Expenditure, 1963–1973*. London: Her Majesty's Stationery Office.

———. Various dates. *Annual Abstract of Statistics*. London: Her Majesty's Stationery Office.

———. *National Income and Expenditure*, annual volumes from 1954 through 1966. London: Her Majesty's Stationary Office.

Chenery, H., and Syrquin, M. 1975. *Patterns of development 1950–1970*. New York: Oxford University Press.

Christensen, L. R. 1971. Entrepreneurial income: how does it measure up? *American Economic Review* 61: 575–85.

Christensen, L. R., and Cummings, D. 1976. *Real product, real factor input, and productivity in Canada, 1947–1973*. Social Systems Research Institute, University of Wisconsin, Discussion Paper no. 7604.

———. 1979. *Real product, real factor input, and productivity in Korea, 1960–1973*. Social Systems Research Institute, University of Wisconsin, Discussion Paper no. 7917.

Christensen, L. R.; Cummings, D.; and Norton, B. 1979. *Real product, real factor input, and productivity in Italy, 1952–1973*. Social Systems Research Institute, University of Wisconsin, Discussion Paper no. 7918.

Christensen, L. R.; Cummings, D.; and Schoeck, P. 1975. *Real product, real factor input, and productivity in the Netherlands, 1951–1973*. Social Systems Research Institute, University of Wisconsin, Discussion Paper no. 7529.

Christensen, L. R.; Cummings, D.; Doerner, D.; and Singleton, K. 1975. *Real product, real factor input, and productivity in the United Kingdom, 1955–1973*. Social Systems Research Institute, University of Wisconsin, Discussion Paper no. 7530.

Christensen, L. R., and Jorgenson, D. W. 1969. Measurement of U.S. real capital input, 1929–1967. *Review of Income and Wealth*, ser. 15, no. 4: 293–320.

———. 1970. U.S. real product and real factor input, 1929–1967. *Review of Income and Wealth*, ser. 16, no. 1: 19–50.

———. 1973*a*. Measuring the performance of the private sector of the U.S. economy, 1929–1969. In M. Moss, ed., *Measuring economic and social performance*. New York: National Bureau of Economic Research, pp. 233–338.

———. 1973*b*. U.S. income, saving and wealth, 1929–1969. *Review of Income and Wealth*, ser. 19, no. 4 (December): 329–62.

Christensen, L. R.; Jorgenson, D. W.; and Lau, L. J. 1971. Conjugate duality and the transcendental logarithmic production function. *Econometrica* 39, no. 4 (July): 255–56.

———. 1973. Transcendental logarithmic production frontiers. *Review of Economics and Statistics* 55, no. 1 (February): 28–45.

Conrad, K., and Jorgenson, D. W. 1975. *Measuring performance in the private economy of the Federal Republic of Germany, 1950–1973.* Tubingen: J. C. B. Mohr.

Correa, H. 1970. Sources of economic growth in Latin America. *Southern Economic Journal* 37, no. 1 (July): 17–31.

Cummings, D., and Meduna, L. 1973. *The Canadian consumer accounts.* Ottawa: Research Projects Group, Strategic Planning and Research, Department of Manpower and Immigration.

Danielson, R. S. 1975. *Output and input data for Canadian agriculture, 1926–1970.* Ottawa: Research Projects Group, Strategic Planning and Research, Department of Manpower and Immigration.

Dean, G. 1964. The stock of fixed capital in the United Kingdom in 1961. *Journal of the Royal Statistical Society*, ser. A [General], vol. 127, pt. 3: 327–58.

de Meo, G. 1973. Sintesi statistica du un ventennio di vita economica italiana. *Annali di statistica*, ser. 8, vol. 27.

Denison, E. F. 1962. *Sources of economic growth in the United States and the alternatives before us.* Supplementary Paper 13, Committee for Economic Development.

———. 1967. *Why growth rates differ.* Washington: The Brookings Institution.

———. 1969. Some major issues in productivity analysis: an examination of estimates by Jorgenson and Griliches. *Survey of Current Business* 49, no. 5, pt. 2 (May): 1–27.

———. 1972. Final comments, *Survey of Current Business* 52, no. 5, pt. 2 (May): 95–110.

———. 1974. *Accounting for United States economic growth 1929–1969.* Washington: The Brookings Institution.

Denison, E. F., and Chung, W. 1976. *How Japan's economy grew so fast.* Washington: The Brookings Institution.

Department of Employment. 1971. *British Labour Statistics: Historical Abstract 1886–1968.* London: Her Majesty's Stationery Office.

———. *British Labour Statistics Yearbook*, annual volumes from 1969 through 1973. London: Her Majesty's Stationery Office.

Diewert, W. E. 1976. Exact and superlative index numbers. *Journal of Econometrics* 4, no. 2 (May): 115–46.

Divisia, F. 1925. L'indice monétaire et la théorie de la monnaie. *Revue d'économie politique*, 39e Année, no. 4 (July-August): 842–61; no. 5 (September-October): 980–1008; no. 6 (November-December): 1121–51.

———. 1926. L'indice monétaire et la théorie de la monnaie. *Revue d'économie politique*, 40e Année, no. 1 (January-February): 49–81.

Domar, E.; Eddie, S. M.; Herrick, B. H.; Hohenberg, P. M.; Intriligator, M. D.; and Miyamato, I. 1964. Economic growth and productivity in the United States, Canada, United Kingdom, Germany and Japan in the post-war period. *Review of Economics and Statistics* 46, no. 1 (February): 33–40.

Dominion Bureau of Statistics. 1946. *Census of Canada, 1941*. Ottawa: Queen's Printer.

———. 1953. *Census of Canada, 1951*. Ottawa: Queen's Printer.

———. 1963. *Census of Canada, 1961*. Ottawa: Queen's Printer.

Economic Planning Agency. *Annual report on national income statistics*. Tokyo: Government of Japan.

Economic Planning Board. 1963. *1960 Population and housing census of Korea, 20% sample tabulation report, 11–1 Whole Country*. Seoul: Government of Korea.

———. 1967. *Report on wage survey, 1967*. Seoul: Government of Korea.

———. 1969. *1966 Population census report of Korea, 12–1 Whole Country*. Seoul: Government of Korea.

———. 1970. *Report on wage survey, 1970*. Seoul: Government of Korea.

———. 1973. *1970 Population and housing census report*, vol. 2, *10% Sample Survey, 4–1 Economic Activity*. Seoul: Government of Korea.

———. 1973. *Report on the National Wealth Survey*. Seoul: Government of Korea.

Ezaki, M. 1974. Quantitative study of Japan's economic growth, 1952–1980: an approach from the system of national accounts. Ph.D. diss., Harvard University.

Ezaki, M., and Jorgenson, D. W. 1973. Measurement of macroeconomic performance in Japan, 1951–1968. In K. Ohkawa and Y. Hayami, eds., *Economic growth: the Japanese experience since the Meiji era*, vol. 1. Tokyo: Japan Economic Research Center.

Fabricant, S. 1959. *Basic facts on productivity change*, Occasional Paper 63. New York: National Bureau of Economic Research.

Fisher, I. 1922. *The making of index numbers*. Boston: Houghton Mifflin.

Franco, M. I., ed. 1973. *Rassegna di statistiche del lavoro*, vol. 1. Rome: Istituto centrale di statistica.

Giannone, A. 1963. Evaluations of Italian national wealth in the last fifty years. *Banca Nazionale del Lavoro Quarterly Review* 16, nos. 64–67 (March).

Goldsmith, R., and Saunders, C., eds. 1959. *The measurement of national wealth*. Chicago: Quadrangle Books.

Goldsmith, R. W. 1955. *A study of saving in the United States.* Princeton: Princeton University Press.

———. 1962. *The national wealth of the United States in the postwar period.* New York: National Bureau of Economic Research.

Griliches, Z. 1960. Measuring inputs in agriculture: a critical survey. *Journal of Farm Economics* 42, no. 4 (December): 1411–27.

Griliches, Z., and Jorgenson, D. W. 1966. Sources of measured productivity change: capital input. *American Economic Review* 56, no. 2 (May): 50–61.

Grose, L.; Rottenberg, T.; and Wasson, R. 1969. New estimates of fixed business capital in the United States. *Survey of Current Business* 49, no. 2 (February): 46–52.

Gussman, T. K. 1972. *The demand for durables, nondurables, services and the supply of labour in Canada: 1946–1969.* Ottawa: Research Projects Group, Strategic Planning and Research, Department of Manpower and Immigration.

Hicks, J. R. 1963. *The Theory of Wages.* 2d ed. London: Macmillan.

Hulten, C. R. 1973. Divisia Index Numbers. *Econometrica* 41, no. 6 (November): 1017–26.

Inland Revenue. 1969. *Report of the Commissioner of Her Majesty's Inland Revenue for the year ended 31 March 1969, the 112th Report.* London: Her Majesty's Stationery Office.

———. *Inland Revenue Statistics.* London: Her Majesty's Stationery Office.

International Labour Organization. *Yearbook of Labour Statistics,* annual volumes from 1947 to 1973. Geneva: International Labour Organization.

Institut national de la statistique et des études économiques. 1961. *Annuaire statistique de la France,* vol. 67. Paris: Institut national de la statistique et des études économique.

———. 1963. Les comptes de la nation 1949–1959. *Études et Conjoncture* 18, no. 12 (December): 1105–1257.

———. 1964. *Annuaire statistique de la France,* vol. 70. Paris: Institut national de la statistique et des études économique.

———. 1964. La population active par secteur d'établissement. *Études et conjoncture* 19, no. 3 (March): 9–22.

———. 1970. *Les comptes de la nation, base 1962: résultats d'ensemble des comptes, séries 1959–1966.* Les Collections de l'I.N.S.E.E., série C, no. 7, May.

———. 1970. *Rapport sur les comptes de la nation, 1969.* Les Collections de l'I.N.S.E.E., série C, no. 8, June.

———. 1971. *Les comptes de la nation, base 1962: les comptes de biens et services,* séries 1959–1966. Les Collections de l'I.N.S.E.E., série C, no. 10, May.

———. 1971. *Rapport sur les comptes de la nation 1970*. Les Collections de l'I.N.S.E.E., série C, no. 11, June.

———. 1972. *Les comptes de la nation, base 1962: les comptes des années 1949–1959*. Les Collections de l'I.N.S.E.E., série C, no. 13, April.

———. 1972. *Rapport sur les comptes de la nation 1971*. Les Collections de l'I.N.S.E.E., série C, no. 15, June.

———. 1973. *Rapport sur les comptes de la nation 1972*. Les Collections de l'I.N.S.E.E., série C, no. 23, June.

———. 1973. *Annuaire statistique de la France*, vol. 78. Paris: Institut national de la statistique et des études économique.

———. 1974. *Rapport sur les comptes de la nation 1973*. Les Collections de l'I.N.S.E.E., série C, no. 29–30, June.

Istituto centrale di statistica. 1958. *Ninth census of Italy*, 1951, vol. 7. Rome: Istituto centrale di statistica.

———. 1973. *Annuario di contabilita nazionale*, vol. 111, tome 1 and 2.

———. 1973. *Il valore della lire dal 1861 al 1972*. Rome: Istituto centrale di statistica.

———. *Annali di statistica*, ser. 8, vol. 15–27.

Jorgenson, D. W. 1973. The economic theory of replacement and depreciation. In W. Sellekaerts, ed., *Econometrics and economic theory*. New York: Macmillan, pp. 189–221.

Jorgenson, D. W., and Griliches, Z. 1967. The explanation of productivity change. *Review of Economic Studies* 34, no. 99: 249–83.

———. 1971. Divisia index numbers and productivity measurement. *Review of Income and Wealth*, ser. 18, no. 2 (June): 227–29.

———. 1972*a*. Issues in growth accounting: a reply to Edward F. Denison. *Survey of Current Business* 52, no. 5, pt. 2 (May): 65–94.

———. 1972*b*. Issues in growth accounting: final reply. *Survey of Current Business* 52, no. 5, pt. 2 (May): 111.

Jorgenson, D. W., and Lau, L. J. 1977. *Duality and technology*. Amsterdam: North-Holland.

Kanamori, H. 1972. What accounts for Japan's high rate of growth? *Review of Income and Wealth*, ser. 18, no. 2 (June): 155–72.

Kendrick, J. W. 1956. Productivity trends: capital and labor. *Review of Economics and Statistics* 38, no. 3 (August): 248–57.

———. 1961. *Productivity trends in the United States*. Princeton: Princeton University Press.

———. 1973. *Postwar productivity trends in the United States, 1948–1969*. New York: National Bureau of Economic Research.

———. 1975. Review of Edward F. Denison, "Accounting for United States economic growth, 1929–1969." *Journal of Economic Literature* 13, no. 3 (September): 909–10.

Kennedy, C., and Thirlwall, A. P. 1972. Technical progress: a survey. *Economic Journal* 82, no. 325 (March): 11–72.

Kirner, W. 1968. Zeitreihen für das Anlagevermögen der Wirtschaftsbereiche in der Bundesrepublik Deutschland. *DIW—Beiträge zur Strukturforschung*. Berlin: Deutsches Institut für Wirtschaftsforschung, vol. 5.

Kloek, T. 1966. *Indexcijfers: enige methodologisch aspecten*. The Hague: Pasmans.

Knowles, J. 1954. *Potential economic growth of the United States during the next decade*. Joint Committee on the Economic Report, 83rd Congress, Second Session. Washington: Government Printing Office.

———. 1960. *The potential economic growth in the United States*. Study Paper 20, Joint Economic Committee, 86th Congress, Second Session. Washington: Government Printing Office.

Kuznets, S. 1971. *Economic growth of nations*. Cambridge: Harvard University Press.

Maddison, A. 1972. Explaining economic growth. *Banca Nazionale del Lavoro Quarterly Review*, no. 102 (September): 3–54.

Mairesse, J. 1972. *L'evaluation du capital fixe productif: méthodes et résultats*. Collections de l'I.N.S.E.E., série C, no. 18–19, November.

Manvel, A. 1968. *Three land research studies*. Washington: Government Printing Office.

Mills, E. S., and Song, B. N. 1977. *Korea's urbanization and urban problems, 1945–1975*. Korea Development Institute, Working Paper 7701.

Mills, F. C. 1952. *Productivity and economic progress*. Occasional Paper 38. New York: National Bureau of Economic Research.

Ministère des Affaires Sociales. 1952. *Revue française du travail*, vol. 7, nos. 1–3, January-March.

———. 1954. *Revue française du travail*, vol. 9, no. 1.

———. 1956. *Revue française du travail*, vol. 10, no. 1.

Nadiri, M. I. 1970. Some approaches to the theory and measurement of total factor productivity: a survey. *Journal of Economic Literature* 8, no. 4 (December): 1137–77.

———. 1972. International studies of factor inputs and total factor productivity: a brief survey. *Review of Income and Wealth*, ser. 18, no. 2 (June): 129–54.

Office of Business Economics. 1966. *The national income and product accounts of the United States, 1929–1965, a supplement to the survey of current business*. Washington: U.S. Department of Commerce.

Office of Labor Affairs. 1974. *Year Book of Labor Statistics*. Seoul: Office of Labor Affairs.

Ohkawa, K., et al. 1966. *Shihon Stokku (Capital Stocks)*. Tokyo: Toyokezai.

Organization for Economic Co-operation and Development. *National accounts*, 1950–1968, 1953–1969, 1960–1971, 1961–1972, 1962–1973. Paris: O.E.C.D.

———. *Labor force statistics*, 1956–1966, 1962–1973. Paris: O.E.C.D.

———. *Reviews of national policies for education, Italy*, 1960, 1963, 1966. Paris: O.E.C.D.

Revell, J. 1967. *The wealth of the nation.* Cambridge: Cambridge University Press.

Richter, M. K. 1966. Invariance axioms and economic indexes. *Econometrica* 34, no. 4 (October): 739–55.

Samuelson, P. A. 1953. Prices of factors and goods in general equilibrium. *Review of Economic Studies* 21, no. 1: 1–20.

Schmookler, J. 1952. The changing efficiency of the American economy, 1869–1938. *Review of Economics and Statistics* 34, no. 3 (August): 214–31.

Solow, R. M. 1957. Technical change and the aggregate production function. *Review of Economics and Statistics* 39, no. 3 (August): 312–20.

Statistics Canada. 1974. *1971 Census of Canada.* Labor Force and Individual Income. Ottawa: Information Canada.

———. 1975. *1971 Census of Canada.* Income of Individuals. Ottawa: Information Canada.

———. 1974. Flows and stocks of fixed non-residential capital, Canada. Ottawa: Information Canada.

———. 1974. *National income and expenditure accounts, historical revision, 1926–1971.* Ottawa: Gross National Product Division.

———. 1976. *National income and expenditure accounts*, vol. 1, 1926–1974. Ottawa: Information Canada.

Statistisches Bundesamt. *Fachserie N, Volkswirtschaftliche Gesamtrechnungen.* Reihe 1, Konten und Standardtabellen, 1969, 1970, 1971, 1972 und Vorbericht 1973. Mainz: Verlag W. Kohlhammer.

———. *Statistisches Jahrbuch für die Bundesrepublik Deutschland.* Jahrgange 1952 bis 1973. Mainz: Verlag W. Kohlhammer.

Stigler, G. J. 1947. *Trends in output and employment.* New York: National Bureau of Economic Research.

Stobbe, A. 1969. *Volkswirtschaftliches Rechnungswegen.* Berlin: Springer-Verlag.

Theil, H. 1965. The information approach to demand analysis. *Econometrica* 33, no. 1 (January): 67–87.

Tinbergen, J. 1942. Zur Theorie der langfristigen Wirtschaftsentwicklung, *Weltwirtschaftliches Archiv*, Band 55, no. 1, pp. 511–549; English translation (1959), "On the Theory of Trend Movements," in L. H. Klassen, L. M. Koyck, and H. J. Witteveen, eds., *Jan Tinbergen, Selected Papers.* Amsterdam: North-Holland.

Tornqvist, L. 1936. The Bank of Finland's consumption price index. *Bank of Finland Monthly Bulletin*, no. 10, pp. 1–8.

Valavanis-Vail, S. 1955. An econometric model of growth, U.S.A., 1869–1953. *American Economic Review* 45, no. 2 (May): 208–21.

Vitali, O. 1968. *La formazione del capitale in Italia.* Milan: E.N.I. Pubblicazione della Scuola Enrico Mattei di Studi Superiori sugli Idrocarburi.

Walters, Dorothy. 1968. *Canadian income levels and growth: an international perspective.* Staff Study no. 23, Economic Council of Canada. Ottawa: Queen's Printer.

———. 1970. *Canadian growth revisited.* Staff Study no. 28, Economic Council of Canada. Ottawa: Queen's Printer.

Watanabe, T. 1972. Improvements of labor quality and economic growth—Japan's postwar experience. *Economic Development and Cultural Change* 21, no. 1 (October): 33–53.

Comment

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Summary

The authors are reporting on an intermediate stage of a larger project on intercountry growth experience. They cover nine countries (Canada, France, Germany, Italy, Japan, Korea, the Netherlands, the United Kingdom, and the United States). All of the estimates of input, output, and output in relation to total factor input are by individual years for the period 1947 to 1973 where data are available for the total private sector. The study includes thirteen tables in the text, forty-five appendix tables, with separate, more detailed, reports for individual countries available from the authors.

In many general respects the methods are broadly similar to those that were initially developed to analyze the supply determinants of economic growth in the United States over long periods (usually between years of comparable degrees of demand in relation to supply). These methods have been applied to differences between countries in sources of growth in six previous studies to which the authors refer. There are differences in the concepts used, the countries covered, and time periods examined in the various studies, however.

Recent years have witnessed major changes in the scope of international trade in relation to GNP of all the major industrialized countries, a significant relative narrowing in the real income differences among the industrialized countries, increased trade in manufactured products, differences in the degree of price change between countries, an increased role of the multinational corporation in trade and investment along with more debate about their goals and procedures in host countries, and a series of currency revaluations between industrialized and developing countries that have been more extensive since 1971 than any changes

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since 1949. Economic nationalism has intensified in a number of forms in different countries at the same time that a greater degree of freedom for capital flows and increased international specialization in manufactured products has been occurring.

The longer-term changes in labor supply, education, capital, and the flow of technology, and differences in the speed with which new technologies (both technical and organizational) are adopted in various countries are all important issues, and I welcome more resources in this field. Both government officials and businessmen are too often preoccupied with shorter-term problems, but these longer-term questions do have short-term impacts.

The paper has been extensively revised and rewritten since it was initially presented at Williamsburg, and these comments have been revised to relate to the published version.

Key Concepts

This particular paper departs from some of the previous studies of this type for the United States, and for the growth experience of the other industrialized countries. Some key points will be mentioned, especially where they lead to substantive differences in results from previous work. The study uses factor shares to combine the individual factor inputs, rather than estimating the contribution of labor and capital by econometric methods.

1. The production account is limited to the private domestic sector of each country. This procedure excludes the government sector, which has its own problems in measuring output, and makes output more homogenous for analysis. This same coverage has been followed by Denison in his more recent studies on the United States and Japan, but this has not previously been done for the other countries covered (such as the European countries and Canada).

2. This study imputes a service to consumer durables in each country. This does not seem to change the growth rate of output, but it does add appreciably to the weights used for capital, and increases the share of output in which no productivity increase can occur. For the United States this imputation is more than 10% of private GNP in 1970 and only slightly less for Canada. Table 11.4 shows that the weights for consumer durables are between 8 and 14% of the capital stock for five of the countries covered. If the authors were interested in measuring changes in welfare over time, a procedure of deleting purchases of consumer durables and adding an imputation for services of consumer durables with a measure of net output would have some merit and logic. For their purposes, however, I have serious misgivings.

3. The concept of investment and output is gross in relation to depreciation. While it is consistent to use gross weights for combining inputs

if the analysis is aimed at gross output, and net weights if the net national output is being analyzed; when the stocks of capital per worker are increasing in almost every country according to their estimates, the use of gross weights increases the relative contribution of capital to growth compared to the use of net weights. The debate on this issue has gone on for some time, and it is mentioned to remind the reader that another view persists.

4. They use the double declining balance method of calculating replacement rates for machinery and equipment and nonresidential structures. This makes the ability of an individual capital good to contribute to current production drop implausibly fast. It can also reduce the average service life below what they say they accept, but this version does not clarify how, or whether, they have prevented this.

5. In measuring capital, the authors combine consumer durables, nonresidential structures, producer durables, residential structures, nonfarm inventories, farm inventories, and land (weights for individual categories for individual countries for 1970 are given in table 11.4). The quality adjustment for capital basically reflects the difference in weights between the flows of the services of capital as they measure them and the weights for the stock of capital.

6. On labor input, the only quality adjustment is for education. Age and sex adjustments along the lines recommended in the Gallop-Jorgenson paper given at this conference are not made, but for some countries they are important over this time period. Data are available for a number of countries to do more than they have done, and this version does not go as far in using such data for Canada as the preliminary version.

Comparison of Substantive Results

Although the authors mention six previous studies of international comparisons of growth experience in table 11.1, I will concentrate on the major contrasts with the results from Denison for the United States, the Denison-Poullier results for Northwest Europe, the Denison-Chung results for Japan, and the Walters results for Canada.

1. For seven of the nine countries studied, the results in chapter 11 suggest that the contribution of total factor productivity to the growth in total income is 40% or more. For both periods, the increases in total factor productivity are *greater* absolutely and in relation to total income for every other country than for the United States. This result is in line with most of the results for the same countries that I have seen. An important and interesting question remains as to why the increases in output per unit of total factor input for all the other countries they study, and for all time periods, are larger than for the United States (tables 11.11 and 11.12). However, the authors do not go into the reasons for their results.

2. This study gives a relatively larger contribution to capital than the studies of the Denison type. This arises from the use of weights for capital that include (rather than exclude) capital consumption or depreciation, and from the inclusion of a weight for the stock of consumer durables. This contributes to a different split of total output change between total factor input change and total factor productivity change. Thus, for example, in the case of Canada, while the results on total factor productivity are roughly comparable, the contribution of capital is much greater and the contribution of labor quality is much less (and the contribution of education is somewhat less) than in the study by Dorothy Walters. My own preference is to analyze net output (excluding the imputation for services of consumer durables) and to use *net* national income weights rather than gross. This would significantly reduce the relative contribution of capital to the growth of total inputs and reduce the rate of growth in total factor input for most countries for both periods studied.

3. The result in table 11.11, that the increase in total factor productivity for the postwar period has been greater for the United Kingdom than for the United States and Canada, is hard to accept or explain. As pointed out by Professor O. J. Firestone at the Williamsburg conference, most other studies of the same countries show the United Kingdom as the lowest, a result in line with their recurrent balance of payments problems and the assessment of most observers both inside and outside the United Kingdom.

Questionable Empirical Techniques

The authors are interested in a logically consistent set of production, wealth, saving, and capital-formation accounts in current and constant prices. In implementing this, the authors sometimes make compromises for the sake of expediency which are disturbing. Let me mention some points which warrant consideration!

1. Table 11.A.4C and the related Canadian series on labor quality show a slightly smaller increase from 1960 to1973 than from 1947 to 1960, although the differences are less in the current paper than in the one presented at the conference. During the later period, the number of young people coming of labor-force age was three times the number reaching retirement age, and the differences in education levels were dramatic. The proportion going to university was up sharply and the proportion finishing high school was also up. Moreover, the increases were particularly large in the educational categories with the highest income. In view of these facts, their results are hard to explain. It is difficult to believe that the use of income weights to combine educational attainments of the various labor-force groups could completely wipe out the effect of this more rapid rise in educational level.

2. There is no reference to the fact that the procedures used to derive construction deflators for Canada, France, and the U.S. differ from the procedures used for the other countries, with the former procedures allowing for the impact of productivity change in the construction industry and the latter not. This affects comparability of changes over time in both the output and capital input measures.

3. For some countries, the authors continue to follow the practice of using the wholesale price indexes for deflating the stocks of nonfarm and farm inventories. This procedure can introduce an inappropriate set of weights. Some types of inventories have a very fast turnover, while others have a slow turnover, and thus the use of shipment weights (as are reflected in the wholesale price index) can introduce errors. Further, during a period of rising prices the accounting conventions followed should be allowed for by using prices over *previous* months, rather than the end of the period. This discussion does not refer to, and should not be confused with, the deflation of changes in inventory investment.

4. Their estimates of labor quality change associated with education look peculiar for some other countries in addition to Canada. The contribution of education shown for Japan in table 11.13 seems low in light of detailed data for that country, even apart from the significant amount of management education and retraining done by private companies. Further, the extent of increase in the index of educational attainment for Italy after 1960 shown in tables 11.13 and 11.A.4I seems unduly large.

Alternative Research Strategy Options

Thus far my comments have dealt with how well Christensen, Cummings, and Jorgenson have done the task they have set themselves. But it is also useful to consider the options open in international growth studies, especially since they point out that six similar previous studies have been published, with four previous ones being done in 1967 or since. These comments relate to future work rather than to the present paper.

1. Decomposing output in relation to total factor inputs: It is now clear that many countries have been obtaining significant increases in total factor productivity. Could this be due to such temporary factors as variations in demand pressure and agricultural output? This is more important when data for individual years are being produced than when growth rates over a series of years were being analyzed. The extent of shifts out of agriculture and self-employment have been much more important for France, Germany, Japan, and Canada than for the United States. What about the effects of tariff reductions in Europe and Canada? These need study to assess the prospects for continued high increases

in total factor productivity and to assess policies for influencing economic growth in the countries being studied.

2. Comparisons of levels of output in relation to total factor input: It is clear from *Why Growth Rates Differ* and the comparable studies for Canada and Japan that additional perspective on growth is obtained from studies at a point in time *in addition to* changes over time, rather than doing either one in isolation. It has also been established that the methods are applicable to comparisons at a point in time. Are different countries' levels of real income per person employed converging? Most of the countries covered in the Christensen-Cummings-Jorgenson paper were also covered in the International Comparisons Project by Kravis and his associates. On the whole, the differences between North America, Europe, and Japan have narrowed since the Second World War. This paper suggests that this is also happening for Korea, but this may not be the pattern in other developing countries. The study by Kravis and his associates would facilitate further analysis of the differences in level, and I hope that further work along this line will be done. It is not possible to do this from material now in the public domain as the differences in inputs between countries at a point in time are not available (especially capital stock and the quality of capital stock).

3. Industrial disaggregation: Much more attention needs to be given to the commodity producing industries, as the results for the economy as a whole and for the private sector are so heavily influenced by services and nontraded goods that are produced and consumed on a local basis. The paper at this session by Yamada and Ruttan on agriculture shows the illumination that can be provided. The U.S. Department of Labor's study of the steel industry in various countries also shows the possibilities. Another example is the recently published volume by Scherer, et al., *The Economics of Multi-Plant Operation: An International Comparisons Study* covering twelve industries in six nations. Much more study on differences within manufacturing industries between countries at a point in time is desirable, and we are aware from the Canada–U.S. work of the data and resource problems that are involved. In my opinion, however, this would be preferable, to further studies of aggregative changes over time. More work on manufacturing, agriculture, and natural resource industries would facilitate the integration of work on growth with the related areas of international trade and balance of payments.

Professor Jorgenson recognizes the desirability of additional industrial disaggregation, as in the Gallop-Jorgenson paper earlier in the current volume, and he has underway a further project comparing output and labor and capital inputs for individual manufacturing industries in Japan and the United States. Additional work by authors in the profession would also be desirable.

Reply

L. R. Christensen, D. Cummings, and D. W. Jorgenson

Daly correctly emphasizes the central importance of our approach to the measurement of capital input in our analysis of economic growth. Our methodology has very significant implications for the allocation of growth among its sources, and our results provide a very different picture from that suggested by earlier studies, such as those by Denison and his associates cited by Daly. It should also be emphasized that we cover a much broader range of historical experience.

In view of the importance of capital measurement we have taken considerable pains to provide a detailed rationale for our approach. Growth rates of inputs are weighted by their income shares; both output and income shares include depreciation. Depreciation is part of the annualized cost of using capital input, and the marginal productivity of capital is understated if depreciation is omitted. Daly concedes that our weights are appropriate for an analysis of economic growth based on gross private domestic product, the concept of output we employ.

However, Daly goes on to state his preference for a measure of productivity based on measures of output and income shares for capital that are net of depreciation. Denison and his associates have failed to supply a convincing rationale for this approach, and Daly fails to provide one. Daly also fails to confront three additional issues in capital measurement: (1) inconsistency between capital weights and capital stock measures; (2) failure to incorporate differences among capital weights due to differences in the taxation of income from capital; (3) inconsistency between the own rates of return for individual capital goods used in capital input weights and data on revaluations of assets from national wealth accounts. We must conclude that Daly's preference for net measures is unsupported and unsupportable.

Our measures of capital stock and our weights for capital input are based on declining balance depreciation and replacement. For each country we have used the best information available to estimate the replacement rates for the various classes of capital stock. For example, for Canada we employ the replacement rates implicit in the capital stock study by Statistics Canada.[1] For the United States we employ double declining balance replacement rates, one of the alternatives provided by the Bureau of Economic Analysis (U.S. Department of Commerce) in their capital stock study. The resulting capital stocks and capital input weights appear to be very reasonable for all countries included in our study.

1. *Fixed Capital Flows and Stocks, 1926–1973*. Information Canada, catalog 13–211.

Daly correctly points out that the stock of consumer durables is substantial for the U.S. and for some of the other countries in our study. He suggests that this large portion of the capital stock be omitted from our study. It may be desirable to consider subsets of the total capital stock for some purposes; but we believe that the full stock should be used in the analysis of sources of economic growth.

Daly expresses concern over our index of labor quality, especially for Canada. The Canadian census figures which we used are consistent with Daly's notion of the average years of education. This measure increased approximately 6% in the forties, 8% in the fifties, and 10% in the sixties. However, a correct accounting for the growth of labor input requires that the rates of growth of the various segments of the labor force be weighted by their shares in total labor earnings. When this is done, the growth of the quality of labor is much more modest than the growth of years of education per worker. Similar observations apply to our labor input indexes for other countries. In all cases our estimates are based on official census data.

Daly suggests that we use inappropriate deflators for stocks of inventories. We employ inventory stock deflators whenever they are available. In some countries, however, such deflators are simply not available. For countries which have inventory stock deflators, they do not differ substantially from wholesale price indexes. Therefore, we felt justified in using wholesale price indexes when inventory stock deflators were not available. For inventory investment flows we employ implicit deflators from the official national accounts for each country.

In a more positive vein, Daly outlines a very useful agenda for future research involving international comparisons. Analyzing sources of changes in total factor productivity and comparing levels as well as rates of growth of productivity are worthwhile objectives. We feel that disaggregation of growth sources by industry will uncover an important component of change in productivity at the aggregate level by quantifying the effects of shifts in resources among industries.

In concluding, it is a pleasure to thank Daly for the care he has taken in preparing his comments on our paper. We have found his views, expressed orally at the conference and in subsequent correspondence, to be very valuable in revising the paper for publication.