IMES DISCUSSION PAPER SERIES

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Discussion Paper No. 99-E-11

INSTITUTE FOR MONETARY AND ECONOMIC STUDIES

BANK OF JAPAN

C.P.O BOX 203 TOKYO
100-8630 JAPAN

IMES Discussion Paper Series 99-E-11
May 1999

WHATEVER HAPPENED TO PRODUCTIVITY INVESTMENT AND GROWTH IN THE G-7?

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Abstract

In this paper we present international comparisons of patterns of economic growth among the G-7 countries over the period 1960-1995. We can rationalize the important changes in economic performance that have taken place among the G-7 countries on the basis of Robert Solow's neoclassical theory of economic growth. In Section 2 we describe the methodology for allocating the sources of economic growth between investment and productivity. In Section 3 we analyze the role of investment and productivity as sources of growth in the G-7 countries over the 1960-1995. In Section 4 we test the important implication of the neoclassical theory of growth that relative levels of output and input per capita must converge over time. In Section 5 we summarize the conclusions of our study and outline alternative approaches to endogenous growth through broadening the concept of investment. The mechanism for endogenous accumulation of tangible assets captured in Solow's theory provides the most appropriate point of departure. Investment in human capital, especially investment in education, can now be incorporated into the theory. When measures of the output of research and development activities become available, investment in intellectual capital can be made endogenous.

Key words: Neoclassical growth theory; Investment and Productivity; Human capital; Intellectual capital; R&D; Sources of economic growth.

JEL classification: O47, E13, E22, E23

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This paper was prepared for the Eighth International Conference, "Monetary Policy in a world of Knowledge-Based Economy, and Quality Change and Uncertain Measurement," held by Institute for Monetary and Economic Studies, Bank of Japan, on June 18-19, 1998. We gratefully acknowledge financial support by the Program on Technology and Economic Policy of Harvard University. Responsibility for any remaining deficiencies rests solely with the authors.

1. Introduction.

In this paper we present international comparisons of patterns of economic growth among the G7 countries over the period 1960-1995. Between 1960 and 1973 productivity growth accounted for more than half of growth in output per capita for France, Germany, Italy, Japan, and the U.K. and somewhat less than half of output growth in Canada and the U.S. The relative importance of productivity declined substantially after 1973, accounting for a predominant share of growth between 1973 and 1989 only for France.

Since 1989 productivity growth has almost disappeared as a source of economic growth in the G7 countries. Between 1989 and 1995 productivity growth was negative for five of the G7 countries, with positive growth only for Japan and the U.S. The level of productivity for Canada in 1995 fell almost to the level first achieved in 1973, while declines in Italy and the U.K. brought productivity down to the levels of 1974 and 1978, respectively. Since 1989 input per capita has grown more slowly than the average for the period 1960 to 1989, except for Germany.

The United States has retained its lead in output per capita throughout the period 1960-1995. The U.S. has also led the G7 countries in input per capita, while relinquishing its lead in productivity to France. However, the U.S. has lagged behind Canada, France, Germany, Italy, and Japan in the growth of output per capita, surpassing only the United Kingdom. Except for Germany and the

U.K., the U.S. has lagged behind all the G7 countries in growth of input per capita, while U.S. productivity growth has exceeded only that of Canada and the U.K.

Japan exhibited considerably higher growth rates in output per capita and productivity than the other G7 countries from 1960 to 1995, but most of these gains took place before 1973. Japan's productivity level, along with the levels of Germany and Italy, remain among the lowest in the G7. Japan's performance in output per capita owes more to high input per capita than to high productivity. The growth of Japanese input per capita greatly exceeded that for other G7 countries, especially prior to 1973.

During the period 1960-1995, economic performance among the G7 countries has became more uniform. The dispersion of levels of output per capita fell sharply before 1970 and has declined modestly since then. The dispersion in productivity levels also fell before 1970 and has remained within a narrow range. The dispersion of levels of input per capita has been stable throughout the period from 1960 to 1995. However, the relative positions of the G7 countries have been altered considerably with the dramatic rise of Japan and the gradual decline of the U.K.

We can rationalize the important changes in economic performance that have taken place among the G7 countries on the basis of Robert Solow's (1956) neoclassical theory of economic growth, extended to incorporate persistent differences among countries. Productivity growth is exogenous, while investment is endogenous to the theory. Obviously, the relative importance of exogenous productivity growth has been greatly reduced, while a more prominent role must be assigned to endogenous investment in tangible assets and human capital.

In Section 2 we describe the methodology for allocating the sources of economic growth between investment and productivity. We introduce constant quality indices of capital and labor inputs that incorporate the impacts of investments in tangible assets and human capital. The constant quality index of labor input combines different types of hours worked by means of relative wage rates. The constant quality index of capital input weights different types of capital stocks by rental rates, rather than the asset prices used for weighting capital stocks.

Differences in wage rates for different types of labor inputs reflect investments in human capital through education and training, so that a constant quality index of labor input is the channel for the impact of these investments on economic performance. The constant quality index of capital input includes a perpetual inventory of investments in tangible assets. The index also incorporates differences in rental prices that capture the differential impacts of these investments. In Section 3 we analyze the role of investment and productivity as sources of growth in the G7 countries over the period 1960-1995. We sub-divide this period at 1973 to identify changes in performance after the first oil crisis. We employ 1989 as another dividing point to focus on the most recent experience. We decompose growth of output per capita for each country between growth of productivity and growth of input per capita. Finally, we decompose the growth of input per capita into components associated with investments in tangible assets and human capital.

International comparisons reveal important similarities among the G7 countries. Investments in tangible assets and human capital now account for the overwhelming proportion of economic growth in the G7 countries and also explain the predominant share of international differences in output per capita. Heterogeneity in capital and labor inputs and changes in the composition of these inputs over time are essential for identifying persistent international differences and accounting for growth.

In Section 4 we test the important implication of the neoclassical theory of growth that relative levels of output and input per capita must converge over time. For this purpose we employ the coefficient of variation to measure convergence of levels of output per capita, input per capita, and productivity among the G7 countries over the period 1960-1995. As before, we divide the period at 1973 and 1989. We also analyze the convergence of capital and labor inputs per capita implied by the theory.

In Section 5 we summarize the conclusions of our study and outline alternative approaches to endogenous growth through broadening the concept of investment. The mechanism for endogenous accumulation of tangible assets captured in Solow's theory provides the most appropriate point of departure. Investments in human capital, especially investment in education, can now be incorporated into the theory. When measures of the output of research and development activities become available, investment in intellectual capital can be made endogenous.

2. Investment and Productivity.

On-going debates over the relative importance of investment and productivity in economic growth coincide with disputes about the appropriate role for the public sector. Productivity can be identified with "spillovers" of benefits that fail to provide incentives for actors within the private sector. Advocates of a larger role for the public sector advocate the position that these spillovers can be guided into appropriate channels by an all-wise and beneficent government. By contrast proponents of a smaller government search for methods of decentralizing investment decisions among participants in the private sector.

Profound differences in policy implications militate against any simple resolution of the debate on the relative importance of investment and productivity. Proponents of income redistribution will not lightly abandon the search for a "silver bullet" that will generate economic growth without the necessity of providing incentives for investment. Advocates of growth strategies based on capital formation will not readily give credence to claims of spillovers to beneficiaries who are difficult or impossible to identify.

To avoid the semantic confusion that pervades popular discussions of economic growth it is essential to be precise in defining investment. Investment is the commitment of current resources in the expectation of future returns and can take a multiplicity of forms. The distinctive feature of investment as a source of economic growth is that the returns can be internalized by the investor.

The most straightforward application of this definition is to investment in tangible assets that creates property rights, including rights to the incomes that accrue to the owners of the assets.

The mechanism by which tangible investments are translated into economic growth is well understood. For example, an investor in a new industrial facility adds to the supply of these facilities and generates a stream of property income. Investment and income are linked through markets for capital assets and their services. The increase in capital input contributes to output growth in proportion to the marginal product of capital. The stream of property income can be divided between capital input and its marginal product. Identifying this marginal product with the rental price of capital provides the basis for a constant quality index of capital input.

The seminal contributions of Gary Becker (1993), Fritz Machlup (1962), Jacob Mincer (1974), and Theodore Schultz (1961) have given concrete meaning to a notion of wealth including investments that do not create property rights. For example, a student enrolled in school or a worker participating in a training program can be viewed as an investor. Although these investments do not create assets that can be bought or sold, the returns to higher educational qualifications or better skills in the workplace can be internalized by the investor.

An individual who completes a course of education or training adds to the supply of people with higher qualifications or skills. The resulting stream of labor income can be divided between labor input and its marginal productThe increase in labor contributes to output growth in proportion to the marginal product. Identifying this marginal product with the wage rate provides the basis for a constant quality index of labor input. While there are no asset markets for human capital, investments in human and nonhuman capital have the common that returns to these investments can be internalized.

The defining characteristic of productivity as a source of economic growth is that the incomes generated by higher productivity are external to the economic activities that generate growth. Publicly supported research and development programs are a leading illustration of activities that stimulate productivity growth. These programs can be conducted by government laboratories or financed by public subsidies to private laboratories. The resulting benefits are external to the economic units conducting the research and development. These benefits must be carefully distinguished from the private benefits of research and development that can be internalized through the creation of intellectual property rights.[1]

The allocation of sources of economic growth between investment and productivity is critical for assessing the explanatory power of growth theory. Only substitution between capital and labor inputs resulting from investment in tangible assets is endogenous in Solow's (1956) neoclassical theory of growth. However, substitution among different types of labor inputs is the consequence of investment in human capital, while investment in tangible assets induces

[1]Zvi Griliches (1992, 1995) has provided detailed surveys of spillovers from investment in research and development. Griliches (1992) gives a list of survey papers on spillovers.

substitution among different types of capital inputs. Neither form of substitution is incorporated into Solow's (1957) model of production.

The distinction between substitution and technical change emphasized by Solow (1957) parallels the distinction between investment and productivity as sources of economic growth. However, Solow's definition of investment, like that of Simon Kuznets (1971), was limited to tangible assets. Both specifically excluded investments in human capital by relying on increases in undifferentiated hours of work as a measure of the contribution of labor input.

The contribution of investment in tangible assets to economic growth is proportional to the rental price of capital, which reflects the marginal product of capital. By contrast the asset price of capital reflects the present value of the income from a capital asset over its entire lifetime. Both Kuznets (1971) and Solow (1970) identified the contributions of tangible assets to growth with increases in the stock of capital, weighted by asset prices. By failing to employ the marginal products of tangible assets as weights, Kuznets and Solow mis-allocated the sources of economic growth between investment in tangible assets and productivity.[2]

[2] The measurement conventions of Kuznets and Solow remain in common use. See the references given by Jorgenson (1990) and the following recent examples: Martin Baily and Charles Schultze (1990), Robert Gordon (1990), Steven Englander and Andrew Gurney (1994), Lawrence Lau (1996), and Robert Hall and Charles Jones (1997).

Investment can be made endogenous within a neoclassical growth model, while productivity growth is exogenous. If productivity greatly predominates among sources of growth, as indicated by Kuznets (1971) and Solow (1970), most of growth is determined exogenously. Reliance on the "Solow residual" as an explanatory factor is a powerful indictment of the limitations of the neoclassical framework. This viewpoint was expressed by Moses Abramovitz (1956), who famously characterized the Solow residual as A Measure of Our Ignorance.

Jorgenson and Griliches (1967) introduced constant quality indices of capital and labor inputs and a constant quality measure of investment goods output in allocating the sources of growth between investment and productivity. This greatly broadened the concept of substitution employed by Solow (1957) and altered, irrevocably, the allocation of economic growth between investment and productivity. They showed that eighty-five percent of U.S. economic growth could be attributed to investment, while productivity accounted for the only fifteen percent.[3]

[3]Jorgenson and Griliches (1967), Table IX, p. 272, attributed thirteen percent of growth to the relative utilization of capital, measured by energy consumption as a proportion of capacity; however, this is inappropriate at the aggregate level, as Edward Denison (1974), p. 56, pointed out. For additional details, see Jorgenson, Frank Gollop, and Barbara Fraumeni (1987), especially pp. 179-181.

The measure of labor input employed by Jorgenson and Griliches combined different types of hours worked, weighted by wage rates, into a constant quality index of labor input, using methodology Griliches (1960) had developed for U.S. agriculture.[4] Their constant quality index of capital input combined different types of capital inputs by means of rental rates, rather than the asset prices appropriate for measuring capital stock. This model of capital as a factor of production was introduced by Jorgenson (1963) and made it possible to incorporate differences in capital consumption and the tax treatment of different types of capital income.[5]

Jorgenson and Griliches identified technology with a production possibility frontier. This extended the aggregate production function -- introduced by Paul Douglas (1948) and developed by Jan Tinbergen (1942) and Solow (1957) -- to include two outputs, investment and consumption goods. Jorgenson (1966) showed that economic growth could be interpreted, equivalently as "embodied" in investment in the sense of Solow (1960) or "disembodied" in

[4]Constant quality indices of labor input are discussed in detail by Jorgenson, Frank Gollop, and Barbara Fraumeni (1987), Chapters 3 and 8, pp. 69-108 and 261-300, Bureau of Labor Statistics (1993), and Ho and Jorgenson (1998).

[5]Detailed surveys of empirical research on the measurement of capital input are given by Jorgenson (1996) and Jack Triplett (1996). BLS (1983) compiled an constant quality index of capital input for its official estimates of productivity, renamed as *multifactor productivity*. BLS retained hours worked as a measure of labor input until July 11, 1994, when it released a new multifactor productivity measure incorporating a constant quality index of labor input.

productivity growth. Jorgenson and Griliches removed this indeterminacy by introducing constant quality indices for investment goods.[6]

Laurits Christensen and Jorgenson (1969, 1970) imbedded the measurement of productivity in a complete system of U.S. national accounts. They provided a much more detailed model of capital input based on the framework for the taxation of corporate capital income developed by Hall and Jorgenson (1967, 1969, 1971). Christensen and Jorgenson extended this framework to include noncorporate and household capital incomes. This captured the impact of differences in returns to different types of capital inputs more fully.

Christensen and Jorgenson identified the production account with a production possibility frontier describing technology and the income and expenditure account with a social welfare function describing consumer preferences. Following Kuznets (1961), they divided the *uses* of economic growth between consumption and saving. They linked saving to the wealth account through capital accumulation equations for each type of asset. Prices for different vintages of assets were linked to rental prices of capital inputs through a parallel set of capital asset pricing equations.

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[6] A detailed history of constant quality price indices is given by Ernst Berndt (1991). Gordon (1990) constructed constant quality indices for all types of producers' durable equipment in the national accounts and Paul Pieper (1989, 1990) provided constant quality indices for structures.

In 1973 Christensen and Jorgenson constructed internally consistent income, product, and wealth accounts. Separate product and income accounts are integral parts of both the U.S. Income and Product Accounts[7] and the United Nations (1968) *System of National Accounts* designed by Richard Stone.[8] However, neither system included wealth accounts consistent with the income and product accounts.

Christensen and Jorgenson constructed income, product, and wealth accounts, paralleling the U.S. National Income and Product Accounts for the period 1929-1969. They also implemented a vintage accounting system for the U.S. on an annual basis. The complete system of vintage accounts gave stocks of assets of each vintage and their prices. The stocks were cumulated to obtain asset quantities, providing the perpetual inventory of assets employed by Raymond Goldsmith (1955-6, 1962).

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[7]See Bureau of Economic Analysis (1995).

[8]The United Nations System of National Accounts (SNA) is summarized by Stone (1992) in his Nobel Prize address. The SNA has been revised by the Inter-Secretariat Working Group on National Accounts (1993).

The key innovation was the use of asset pricing equations to link the prices used in evaluating capital stocks and the rental prices employed in the constant quality index of capital input.[9] In a prescient paper on the measurement of welfare Paul Samuelson (1961) had suggested that a link between asset and rental prices was essential for the integration of income and wealth accounting.[10] The vintage system of accounts employed the specific form of this relationship developed by Jorgenson (1967).

Christensen, Dianne Cummings, and Jorgenson (1981) presented annual estimates of sources of economic growth for the United States and its major trading partners for the period 1960-1973. These estimates included constant quality indexes of capital and labor input for each country.

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[9]Constant quality price indices for investment goods of different ages or vintages were developed by Hall (1971). This made it possible for Charles Hulten and Frank Wykoff (1982) to estimate relative efficiencies by age for all types of tangible assets, putting the measurement of capital consumption required for constant quality index of capital input onto a firm empirical foundation. BEA (1995) has adopted this approach in the latest benchmark revision of the U.S. National Income and Product Accounts, following methodology described by Fraumeni (1997).

[10]See Samuelson (1961), especially p. 309.

Our first objective in this paper is to extend these estimates to 1995 for the G7 countries.[11] We have chosen GDP as a measure of output. We include imputations for the services of consumers' durables as well as land, buildings and equipment owned by nonprofit institutions in order to preserve comparability in the treatment of income from different types of capital.

Our constant quality index of capital input is based on a disaggregation of the capital stock among the twenty-one categories given in Table 1. These are classified by asset type and ownership to reflect differences in capital consumption and tax treatment among assets. We derive estimates of capital stock and property income for each type of capital input from national accounting data. Similarly, our constant quality index of labor input is based on a disaggregation of the work force among the twenty categories presented in Table 2. These are classified by sex, educational attainment, and employment status. For each country we derive estimates of hours worked and labor compensation for type of labor input from labor force surveys.

[11] Dougherty and Jorgenson (1996, 1997) have updated the estimates of Christensen, Cummings, and Jorgenson (1981) through 1989.

3. Sources of Growth.

In Table 4 we present output per capita for the G7 countries over the period 1960-1995, expressed relative to the U.S. in 1985. We use 1985 purchasing power parities from the OECD (1987) to convert quantities of output per capita from domestic currencies for each country into U.S. dollars. The U.S. was the leader in per capita output throughout the period, while Canada ranked second for most of the period. Among the remaining five countries the U.K. started at the top and Japan at the bottom; by 1995 these roles were interchanged with Japan overtaking all four European countries and the U.K. lagging behind these countries, except for Italy.

In Table 4 we present input per capita for the G7 countries over the period 1960-1995, relative to U.S. input per capita in 1985. We express quantities of input per capita in U.S. dollars, using purchasing power parities constructed for this study.[12] The U.S. was the leader in per capita input as well as output throughout the period. Germany started in second place, but lost its position to Canada in 1975 and Japan in 1976. In 1995 Japan ranked next to the U.S. in input per capita with Canada third. France started at the bottom of the ranking and remained there for most of the period. Canada, France, Italy, and Japan grew relative to the U.S., while Germany and the U.K. declined.

[12] Our methodology is described in detail by Dougherty (1992).

Finally, in Table 4 we present productivity levels for the G7 countries over the period 1960-1995, where productivity is defined as the ratio of output to input. In 1960 the U.S. was the productivity leader with Canada closely behind. In 1970 Canada became the first country to overtake the U.S., remaining slightly above the U.S. level for most of the period ending in 1984. France surpassed the U.S. in 1979 and became the international productivity leader after 1980. The U.K. overtook Canada and nearly overtook the U.S. in 1987, but fell behind both countries in 1990. Japan surpassed Germany in 1970 and Italy in 1990, while Italy overtook Germany in 1963 and maintained its lead during most of the period ending in 1995.

We summarize growth in output and input per capita and productivity for the G7 countries in Table 3. We present annual average growth rates for the period 1960-1989 and 1960-1995 and the subperiods 1960-1973, 1973-1989, and 1989-1995. Japan was the leader in output growth for the period as a whole and before 1973. The U.K. grew more slowly than the remaining six countries during the period as a whole and after 1960. Output growth slowed in all the G7 countries after 1989 and Canada's growth rate was negative. Differences in growth rates among the G7 countries declined substantially after 1973.

Japan also led the G7 in growth of input per capita for the period 1960-1995 and before 1973. Italy was the leader during the subperiod 1973-1989 and Germany led during 1989-1995. There is little evidence of a slowdown in input growth after 1973; differences among input growth rates are much less than among output growth rates. Japan led the G7 in productivity growth for the period as a whole and before 1973, while France was the leader from 1973 to 1989. All the G7 countries - with the exception of Japan and the U.S. - experienced negative productivity growth after 1989. The U.S. had a slightly higher productivity growth rate than Japan during this period. Our constant quality index of capital input weights capital stocks for each of the twenty-one categories given in Table 1 by rental prices, defined as property compensation per unit of capital. By contrast an index of capital stock weights different types of capital by asset prices rather than the rental prices appropriate for capital input. The ratio of capital input to capital stock measures the average quality of a unit of capital, as reflected in its marginal product. This enables us to assess the magnitude of differences between the constant quality index of capital input and the unweighted index of capital stock employed by Kuznets (1971) and Solow (1970).

In Table 6 we present capital input per capita for the G7 countries over the period 1960-1995, expressed relative to the U.S. in 1985. The U.S. was the leader in capital input per capita through 1991, when Canada overtook the U.S. and emerged as the international leader. All countries grew substantially relative to the U.S., but only Canada surpassed the U.S. level. Germany led the remaining five countries throughout the period, while the U.K. was the laggard among these countries, except for the period 1962 to 1973, when Japan ranked lower.

The picture for capital stock per capita has some similarities to capital input, but there are important differences. The U.S. led throughout the period in capital stock, while Canada overtook the U.S. in capital input. France, Germany, and Italy had similar stock levels throughout the period with Italy leading this group of three countries in 1995. Similarly, Japan and the U.K. had similar stock levels throughout the period; Japan ranked last until 1976, but surpassed the U.K. in that year. Capital stock levels do not accurately reflect the substitutions among capital inputs that accompany investments in tangible assets.

Capital quality, presented in Table 6, is the ratio of capital input to capital stock. The behavior of capital quality highlights the differences between the constant quality index of capital input and capital stock. Germany was the international leader in capital quality throughout most of the period 1960-1995, while the U.S. ranked at the bottom. There are important changes in capital quality over time and persistent differences among countries. Heterogeneity of capital input within each country and between countries must be taken into account in international comparisons of economic performance.

We summarize growth in capital input and capital stock per capita and capita quality for the G7 countries in Table 5. Italy was the international leader in capital input growth and the U.S. the laggard for the period 1960-1995. There was a modest slowdown in capital input growth after 1973 and again after 1989 and similar slowdowns in capital stock growth. Italy was the leader in capital quality growth and Japan the laggard.

Our constant quality index of labor input weights hours worked for each of the twenty categories given in Table 2 by wage rates defined in terms of labor compensation per hour. An index of hours worked adds together different types of hours without taking quality differences into account. The ratio of labor input to hours worked measures the average quality of an hour of labor, as reflected in its marginal product. This enables us to assess the magnitude of differences between the constant quality index of labor input and the unweighted index of hours worked employed by Kuznets (1971) and Solow (1970).

In Table 8 we present labor input per capita for the G7 countries for the period 1960-1995, relative to the U.S. in 1985. The U.K. led until 1969, but was overtaken by Japan in that year. The U.S. surpassed the U.K. in 1981, but the two countries grew in parallel through 1995 with the U.S. maintaining a slight lead over most of the period. France ranked at the bottom of the G7 for most of the period, but led Italy from 1963 to 1979. Japan remained the international leader through 1995 with levels of labor input from ten to fifteen percent above the U.S. and the U.K. and almost double that of France.

The picture for hours worked per capita has some similarities to labor input, but there are important differences. Japan was the international leader in hours worked per capita throughout the period, while Germany led the four European countries for most of the period. The U.S. overtook France in 1975 and Germany and the U.K. in 1977. At the beginning of the period Canada ranked last, but lost this position to Italy in 1965. Italy was the laggard in hours worked until 1983, when France fell to the bottom of the G7, remaining there through 1995. Hours worked do not accurately reflect the substitutions among labor inputs that accompany investments in human capital.

Labor quality, presented in Table 8, is the ratio of the constant quality index of labor input to the unweighted index of hours worked. The behavior of labor quality highlights the differences between labor input and hours worked. The U.K. was the leader in labor quality, but was surpassed by Canada in 1981; labor quality in the two countries grew in parallel through 1995. Japan was the laggard among G7 countries in labor quality throughout most of the period 1960-1995, briefly surpassing France in 1977; the two countries grew in parallel for the rest of the period. There are important changes in labor quality over time and persistent differences among countries. Heterogeneity within each country and between countries must be taken into account in international comparisons of economic growth.

We summarize growth in labor input and hours worked per capita and labor quality in Table 7. Japan led the G7 countries in labor input growth for the period 1960-1995 and before 1973. Canada was the international leader during the subperiod 1973-1989, while the U.S. was the leader after 1989. The U.S. led growth in hours worked for the period as a whole and after 1989, while Japan was the leader before 1973 and Italy led between 1973 to 1989. Growth was positive throughout the period for Japan and the U.S., mostly negative for the four European countries, and alternately positive and negative for Canada. Growth in labor quality was positive for all seven countries with a modest decline after 1973 and a revival after 1989. In Table 8 we present labor input and hours worked per capita and labor quality relative to the U.S. in 1985.

In Figure 1 we assess the relative importance of investment and productivity in per capita growth for the G7 countries. For Canada, the U.K., and the U.S. investments in tangible assets and human capital greatly predominated as sources of growth over the period 1960-1995. We attribute slightly more than half of Japanese growth to productivity, while proportions for the four European countries-France, Germany, Italy, and the U.K.-are slightly less than half. After 1973 growth in output and productivity declined for all seven countries; however, growth in input has not declined, so that the relative importance of productivity has sharply diminished.

In Figure 2 we combine estimates of growth in capital input, capital stock, and capital quality to assess the importance of changes in quality. Capital input growth is positive for all countries for the period 1960-1995 and all three subperiods. Capital quality growth is positive for the period as a whole for all G7 countries, except France and Japan. Although capital stock greatly predominates in capital input growth, capital quality is quantitatively significant, so that the heterogeneity of capital must be taken into account in assessing the role of investment in tangible assets.

Finally, in Figure 3 we combine estimates of growth in labor input, hours worked, and labor quality to assess the importance of hours and quality. Labor input growth is negative for the period 1960-1995 in France and Germany, near zero for the U.K. and slightly positive for Italy.

Growth in hours worked is mostly negative for all four countries throughout the period. However, growth in labor quality has helped to offset the decline in hours worked in Europe. For Canada, Japan, and the U. S. labor quality predominates in the growth of labor input, so that the heterogeneity of labor input is essential in assessing the role of investment in human capital.

4. Convergence.

The objective of modeling economic growth is to explain the *sources* and *uses* of growth endogenously. National income is the starting point for assessments of the *uses* of growth through consumption and saving. The concept of a Measure of Economic Welfare, introduced by William Nordhaus and James Tobin (1972), is the key to augmenting national income to broaden the concepts of consumption and saving. Similarly, gross domestic product is the starting point for attributing the *sources* of economic growth to growth in productivity and investments in tangible assets and human capital.

Denison (1967) compared differences in growth rates for national income per person employed for the period 1950-62 with differences of levels in 1960 for eight European countries and the U.S. However, he overlooked the separate roles for a production account with the national product and inputs of capital and labor services and an income and expenditure account with national income,
consumption, and saving. From an economic point of view this ignored the distinction between the *sources* and *uses* of economic growth.

Denison compared differences in both growth rates and levels of national income per person employed. The eight European countries as a whole were characterized by more rapid growth and a lower level of national income per capita. Although this association was not monotonic for comparisons between individual countries and the U.S., Denison concluded that:[13]

> "Aside from short-term aberrations Europe should be able to report higher growth rates, at least in national income per person employed, for a long time. Americans should expect this and not be disturbed by it."

Kuznets (1971) provided elaborate comparisons of growth rates for the fourteen countries included in his study. Unlike Denison (1967), he did not provide level comparisons. Maddison (1982) filled this gap by comparing levels of national product for sixteen countries[14] on the basis of estimates of purchasing power parities by Irving Kravis, Alan Heston, and Robert Summers (1978).[15] These estimates have been updated by successive versions of the Penn World Table and made it possible to reconsider the issue of convergence of output per capita raised by Denison (1967).[16]

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[13]See Denison (1967), especially Chapter 21, "The Sources of Growth and the Contrast between Europe and the United States", pp. 296-348.

[14]Maddison added Austria and Finland to Kuznets' list and presented growth rates covering periods beginning as early as 1820 and extending through 1979. Maddison (1991, 1995) has extended these estimates through 1992

[15]For details see Maddison (1982), pp. 159-168. Purchasing power parities were first measured for industrialized countries by Milton Gilbert and Kravis (1954) and Gilbert (1958).

[16]A complete list through Mark 5 is given by Summers and Heston (1991), while the results of Mark 6 are summarized by The World Bank in the *World Development Report 1993*.

Abramovitz (1986) was the first to take up the challenge of analyzing convergence of output per capita among Maddison's sixteen countries. He found that convergence appeared to characterize output levels in the postwar period, but not the period before 1914 and the interwar period. Baumol (1986) formalized these results by running a regression of growth rate of GDP per hour worked over the period 1870-1979 on the 1870 level of GDP per hour worked.[17] A negative regression coefficient is evidence for "beta-convergence" of GDP levels.

In a notable paper on "Crazy Explanations for the Productivity Slowdown" Paul Romer (1987) derived a version of the growth regression from Solow's (1970) growth model with a Cobb-Douglas production function. Romer also extended the data set for growth regressions from Maddison's (1982) group of sixteen advanced countries to the 115 countries included in Penn World Table (Mark 3), presented by Summers and Heston (1984). Romer's key finding was that an indirect estimate of the Cobb-Douglas elasticity of output with respect to capital was close to three-quarters. The share of capital in output implied by Solow's model was less than half as great on average.[18]

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[17] This "growth regression" has spawned a vast literature, summarized by Ross Levine and David Renelt (1992), Baumol (1994), and Robert Barro and Xavier Sala-i-Martin (1994). Much of this literature has been based on successive versions of the Penn World Table.

[18] Unfortunately, this Mark 3 data set did not include capital input. Romer's empirical finding has spawned a substantial theoretical literature, summarized at an early stage by Robert Lucas (1988) and, more recently, by Gene Grossman and Elhanan Helpman (1991, 1994), Romer (1994) and Barro and Sala-i-Martin (1994). Romer's own important contributions to this literature have focused on increasing returns to scale, as in Romer (1986), and

Gregory Mankiw, David Romer, and David Weil (1992) undertook a defense of the neoclassical framework of Kuznets (1971) and Solow (1970). The empirical portion of their study is based on data for 98 countries from the Penn World Table (Mark 4), presented by Summers and Heston (1988). Like Paul Romer (1987), Mankiw, David Romer, and Weil derived a growth equation from the Solow (1970) model; however, they also augmented this model by allowing for investment in human capital.

The results of Mankiw, David Romer, and Weil (1992) provided empirical support for the augmented Solow model. There was clear evidence of the convergence predicted by the model, where convergence was conditional on the ratio of investment to GDP and the rate of population growth; both are determinants of steady state output. In addition, the estimated Cobb-Douglas elasticity of output with respect to capital coincided with the share of capital in the value of output. However, the rate of convergence of output per capita was too slow to be consistent with 1970 version of the Solow model.

Islam (1995) exploited an important feature of the Summers-Heston (1988) data overlooked in previous empirical studies, namely, benchmark comparisons of levels of the national product at five year intervals, beginning in 1960 and ending in 1985. Using econometric methods for panel data, Islam tested an assumption maintained in growth regressions, such as those of Mankiw,

spillovers from technological change, as in Romer (1990).

David Romer, and Weil. Their study, like that of Paul Romer (1987), assumed identical technologies for all countries included in the Summer-Heston data sets.

Substantial differences in levels of productivity among countries have been documented by Denison (1967), Christensen, Cummings, and Jorgenson (1981), and in Section 2, above. By introducing panel data techniques Islam (1995) was able to allow for these differences. He corroborated the finding of Mankiw, David Romer, and Weil (1992) that the elasticity of output with respect to capital input coincided with the share of capital in the value of output. This further undermined the empirical support for the existence of the increasing returns and spillovers analyzed in the theoretical models of Paul Romer (1986, 1990).

In addition, Islam (1995) found that the rate of convergence of output per capita among countries in the Summers-Heston (1988) data set was precisely that required to substantiate the un-augmented version of the Solow (1970). In short, "crazy explanations" for the productivity slowdown, like those propounded by Paul Romer (1987, 1994), are not required. Moreover, the model did not require augmentation, as suggested by Mankiw, David Romer, and Weil (1992). However, differences in productivity among these countries must taken into account in modeling differences in growth rates.

The conclusion from Islam's (1995) research is that the Solow model is the appropriate point of departure for modeling the accumulation of tangible assets. For this purpose it is unnecessary to endogenize investment in human capital as well. The rationale for this key empirical finding is that the transition path to balanced growth equilibrium requires decades after a change in policies that affect investment in tangible assets, such as tax policies. By contrast the transition after a change in policies affecting investment in human capital requires as much as a century.

In Figure 4 we present coefficients of variation for levels of output and input per capita and productivity for the G7 countries annually for the period 1960-1995. The coefficients for output decline by almost a factor of two between 1960 and 1974, but then remain stable throughout the rest of the period. Coefficients for productivity decline by more than a factor of two between 1960 and 1970 and then stabilize. Coefficients for input per capita are nearly unchanged throughout the period. This is evidence for the "sigma-convergence" of output and input per capita and productivity implied by Solow's neoclassical theory of growth, allowing for differences in productivity of the type identified by Islam.

Figure 5 presents coefficients of variation for levels of capital input and capital stock per capita and capital quality for the G7 countries. The coefficients for capital input decline gradually throughout the period. Coefficients for capital stock are slightly larger than those for capital input, but behave in a similar manner. Coefficients for capital quality are stable until 1968 and then decline to a slightly lower level after 1971. This is also evidence of the sigma-convergence implied by Solow's growth model with persistent differences in levels of capital quality among countries.

Finally, coefficients of variation for levels of labor input and hours worked per capita and labor quality for the G7 are given in Figure 6. The coefficients for labor input are stable through 1983 and then rise gradually. The coefficients for hours worked rise gradually until 1964 and then stabilize for most of the period. The coefficients for labor quality gradually decline. Again, this is evidence for sigma-convergence with persistent international differences in labor quality.

The evidence of sigma-convergence among the G7 countries presented in Figures 4, 5, and 6 is consistent with a new version of Solow's neoclassical growth model, characterized by persistent but stable international differences in productivity, capital quality, labor quality, and hours worked per capita. A simpler version of Solow's model with constant differences in productivity among countries was identified in Islam's research on beta-convergence. This version successfully rationalizes differences in growth of per capita output among a much broader group of countries over the period 1960-1985.

5. Endogenizing Growth.

Constant quality indices of labor input are an essential first step in incorporating investments in human capital into empirical studies of economic growth. Jorgenson and Fraumeni (1989) extended the vintage accounting system developed by Christensen and Jorgenson (1973) to incorporate these investments. The essential idea is to treat individual members of the U.S. population as human assets with "asset prices" given by their lifetime labor incomes. Jorgenson and Fraumeni implemented the vintage accounting system for both human and nonhuman capital for the U.S. on an annual basis for the period 1948-1984.

Asset prices for tangible assets can be observed directly from market transactions in investment goods; intertemporal capital asset pricing equations are used to derive rental prices for capital services. For human capital wage rates correspond to rental prices and can be observed directly from

transactions in the labor market. Lifetime labor incomes are derived by applying asset pricing equations to these wage rates. Lifetime incomes are analogous to the asset prices used in accounting for investment in tangible assets.

Jorgenson and Fraumeni (1992b) have developed a measure of the output of the U.S. education sector. The point of departure is that while education is a service industry, its output is investment in human capital. Investment in education can be measured from the impact of increases in educational attainment on lifetime incomes of all individuals enrolled in school. Investment in education, measured in this way, is similar in magnitude to the value of working time for all individuals in the labor force.

Second, Jorgenson and Fraumeni (1992a) measured the inputs of the education sector, beginning with the purchased inputs recorded in the outlays of educational institutions. A major part of the value of the output of educational institutions accrues to students in the form of increases in their lifetime incomes. Treating these increases as compensation for student time, this time is evaluated as an input into the educational process. Given the outlays of educational institutions and the value of student time, the growth of the education sector can be allocated to its sources.

An alternative approach, employed by Schultz (1961), Machlup (1962), Nordhaus and Tobin (1972), and many others, is to apply Goldsmith's (1955-6) perpetual inventory method to private and public expenditures on educational services. Unfortunately, the approach has foundered on the absence of a satisfactory measure of the output of the educational sector and the lack of an obvious rationale for capital consumption.[19]

[19]For more detailed discussion, see Jorgenson and Fraumeni (1989).

Given vintage accounts for human and nonhuman capital, Jorgenson and Fraumeni (1989) constructed a system of income, product, and wealth accounts, paralleling the system Jorgenson had developed with Christensen. In these accounts the value of human wealth was more than ten times the value of nonhuman wealth, while investment in human capital was five times investment in tangible assets. "Full" investment in the U.S. economy is defined as the sum of these two types of investment. Similarly, the value of nonmarket labor activities is added to personal consumption expenditures to obtain "full" consumption. The product measure included these new measures of investment and consumption.

Since the complete accounting system included a production account with "full" measures of capital and labor inputs,[20] Jorgenson and Fraumeni were able to generate a new set of accounts for the *sources* of U.S. economic growth. The system also included an income and expenditure account with income from labor services in both market and nonmarket activities and an allocation of "full" income between consumption and saving. This provided the basis for the *uses* of U.S. economic growth and a new Measure of Economic Welfare. The system was completed by a wealth account containing both human wealth and tangible assets.

Jorgenson and Fraumeni aggregated the growth of education and noneducation sectors of the U.S. economy to obtain a new measure of U.S. economic growth. Combining this with measures of input growth, they obtained a new set of accounts for the sources of growth. Productivity contributes almost nothing to the growth of the education sector and only a modest proportion to output growth for the economy as a whole, so that productivity accounts for only seventeen percent of growth.

The introduction of endogenous investment in education increases the explanatory power of the theory of economic growth to eighty-three percent. However, it is important to emphasize that growth is measured differently. The traditional framework for economic measurement of Kuznets (1971) and Solow (1970) excludes nonmarket activities, such as those that characterize the major portion of investment in education. The intuition is familiar to any teacher, including teachers of economics: What the students do is far more important than what the teachers do, even if the subject matter is the theory of economic growth.

A third approximation to the theory of economic growth results from incorporating all forms of investment in human capital, including education, child rearing, and addition of new members to the population. Fertility could be made endogenous by using the approach of Barro and Becker (1988) and Becker and Barro (1988). Child rearing could be made endogenous by modeling the household as a producing sector along the lines of the model of the educational sector outlined above. The results presented by Jorgenson and Fraumeni (1989) show that this would endogenize

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[20]Our terminology follows that of Becker's (1965, 1993) theory of time allocation.

eighty-six percent of U.S. economic growth. This is a significant, but not overwhelming, gain in explanatory power.

In principle, investment in new technology could be made endogenous by extending the accounting framework to incorporate investment in new technology. BEA (1994) has provided a satellite system of accounts for research and development, based on Goldsmith's (1955-6) perpetual inventory method, applied to private and public expenditures. Unfortunately, this is subject to the same limitations as the approach to human capital of Schultz (1961) and Machlup (1962). The BEA satellite system has foundered on the absence of a satisfactory measure of the output of research and development and the lack of an appropriate rationale for capital consumption.

The standard model for investment in new technology, formulated by Griliches (1973) is based on a production function incorporating inputs of services from intellectual capital accumulated through investment in research and development. Intellectual capital is treated as a factor of production in precisely the same way as tangible assets in Section 2, above. Bronwyn Hall (1993) has developed the implications of this model for the pricing of the services of intellectual capital input and the evaluation of intellectual capital assets.

The model of capital as a factor of production first proposed by Jorgenson (1963) has been successfully applied to tangible assets and human capital. However, implementation for intellectual capital would require a system of vintage accounts including not only accumulation equations for stocks of accumulated research and development, but also asset pricing equations. These equations are essential for separating the revaluation of intellectual property due to price changes over time from depreciation of this property due to aging. This is required for measuring the quantity of intellectual capital input and its marginal product.

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Table 1
Disaggregation of Capital by Asset Characteristics

Asset Type	**Ownership Sector**
1. Equipment	1. Corporations and government
2. Nonresidential structures	2. Unincorporated businesses
3. Residential structures	3. Households and nonproft institutions
4. Nonfarm inventories	4. General government
5. Farm inventories	
6. Consumer durables	
7. Residential land	
8. Nonresidential land	

Table 2
Disaggregation of Labor by Demographic Characteristics

Sex

Educational Attainment:

1. 1-8 years grade school
2. 1-3 years secondary school
3. Completed secondary school
4. 1-3 years college
5. 4 or more years of college

Employment Status:

1. Business sector employee
2. Self-employed or unpaid family worker
3. General government employee

Table 3 **Growth in Output and Input per Capita and Productivity**

Output per capita

	US	Canada	UK	France	Germany	Italy	Japan
60-73	2.89%	3.20%	2.74%	4.26%	3.74%	4.62%	8.77%
73-89	1.90%	2.45%	1.75%	2.04%	2.15%	2.69%	2.71%
73-95	1.65%	1.68%	1.38%	1.74%	2.02%	2.34%	2.46%
89-95	0.97%	-0.37%	0.42%	0.92%	1.66%	1.40%	1.81%
60-89	2.34%	2.79%	2.19%	3.04%	2.86%	3.56%	5.43%
60-95	2.11%	2.24%	1.89%	2.68%	2.66%	3.19%	4.81%

Input per capita

	US	Canada	UK	France	Germany	Italy	Japan
60-73	1.53%	1.70%	0.98%	2.15%	1.24%	0.79%	2.42%
73-89	1.45%	2.21%	1.10%	0.74%	1.25%	2.42%	2.15%
73-95	1.24%	1.67%	1.28%	0.91%	1.39%	2.17%	2.01%
89-95	0.68%	0.21%	1.77%	1.37%	1.78%	1.49%	1.63%
60-89	1.49%	1.98%	1.04%	1.37%	1.25%	1.69%	2.27%
60-95	1.35%	1.68%	1.17%	1.37%	1.34%	1.66%	2.16%

Productivity

	US	Canada	UK	France	Germany	Italy	Japan
60-73	1.36%	1.51%	1.76%	2.11%	2.50%	3.82%	6.35%
73-89	0.45%	0.23%	0.65%	1.31%	0.90%	0.27%	0.56%
73-95	0.41%	0.01%	0.10%	0.83%	0.62%	0.17%	0.45%
89-95	0.29%	-0.59%	-1.35%	-0.45%	-0.11%	-0.10%	0.18%
60-89	0.86%	0.80%	1.15%	1.67%	1.62%	1.86%	3.16%
60-95	0.76%	0.57%	0.72%	1.30%	1.32%	1.53%	2.65%

Table 4 Levels of Output and Input per capita and Productivity (U.S. = 100.0 in 1985)

Output per capita

	US	Canada	UK	France	Germany	Italy	Japan
1960	55.6	43.1	37.5	29.2	32.9	22.7	17.3
1973	80.9	65.4	53.6	50.9	53.6	41.4	54.0
1989	109.7	96.7	70.8	70.6	75.6	63.7	83.3
1995	116.3	94.6	72.6	74.6	83.5	69.2	92.8

Input per capita

	US	Canada	UK	France	Germany	Italy	Japan
1960	70.2	55.6	53.0	42.5	61.7	44.8	50.1
1973	85.6	69.4	60.1	56.3	72.5	49.7	68.6
1989	108.0	98.8	71.7	63.3	88.5	73.2	96.7
1995	112.5	100.1	79.7	68.7	98.5	80.1	106.7

Productivity

	US	Canada	UK	France	Germany	Italy	Japan
1960	79.2	77.5	70.9	68.8	53.4	50.7	34.5
1973	94.5	94.3	89.1	90.5	73.9	83.3	78.7
1989	101.6	97.9	98.8	111.5	85.4	87.0	86.1
1995	103.4	94.5	91.1	108.6	84.8	86.5	87.0

Table 5 Growth in Capital Input and Capital Stock per Capita and Capital Quality

Capital Input per Capita

	US	Canada	UK	France	Germany	Italy	Japan
60-73	2.32%	3.03%	3.34%	5.15%	6.00%	6.20%	2.93%
73-89	2.03%	3.40%	3.02%	3.06%	3.02%	4.65%	3.63%
73-95	1.68%	2.98%	2.82%	2.82%	2.95%	4.23%	3.51%
89-95	0.74%	1.85%	2.29%	2.19%	2.77%	3.12%	3.18%
60-89	2.16%	3.24%	3.17%	4.00%	4.36%	5.34%	3.32%
60-95	1.92%	3.00%	3.02%	3.69%	4.09%	4.96%	3.29%

Capital Stock per Capita

	US	Canada	UK	France	Germany	Italy	Japan
60-73	1.77%	2.54%	3.06%	5.42%	5.54%	5.01%	2.97%
73-89	1.28%	2.73%	2.68%	3.17%	2.63%	3.52%	3.94%
73-95	1.11%	2.23%	2.48%	2.88%	2.71%	3.42%	3.80%
89-95	0.64%	0.91%	1.94%	2.08%	2.92%	3.15%	3.42%
60-89	1.50%	2.65%	2.85%	4.18%	3.93%	4.18%	3.51%
60-95	1.35%	2.35%	2.69%	3.82%	3.76%	4.01%	3.49%

Capital Quality

	US	Canada	UK	France	Germany	Italy	Japan
60-73	0.55%	0.49%	0.29%	-0.27%	0.46%	1.19%	-0.04%
73-89	0.75%	0.67%	0.35%	-0.11%	0.40%	1.13%	-0.32%
73-95	0.57%	0.75%	0.35%	-0.05%	0.25%	0.81%	-0.30%
89-95	0.09%	0.95%	0.34%	0.10%	-0.15%	-0.03%	-0.24%
60-89	0.66%	0.59%	0.32%	-0.18%	0.43%	1.16%	-0.19%
60-95	0.56%	0.65%	0.32%	-0.14%	0.33%	0.95%	-0.20%

Table 6 Levels of Capital Input and Capital Stock per Capita and Capital Quality (U.S. = 100.0 in 1985)

Capital input per Capita

	US	Canada	UK	France	Germany	Italy	Japan
1960	58.5	41.7	21.0	24.0	26.0	17.1	21.6
1973	79.0	61.9	32.4	46.8	56.6	38.4	31.6
1989	109.4	106.7	52.6	76.4	91.9	80.7	56.4
1995	114.3	119.2	60.4	87.1	108.5	97.3	68.3

Capital Stock per Capita

	US	Canada	UK	France	Germany	Italy	Japan
1960	68.2	43.3	18.8	18.8	20.1	19.6	17.3
1973	85.8	60.3	28.0	38.1	41.3	37.5	25.4
1989	105.3	93.3	42.9	63.4	62.9	65.9	47.8
1995	109.4	98.5	48.2	71.8	74.9	79.6	58.7

Capital Quality

	US	Canada	UK	France	Germany	Italy	Japan
1960	85.8	96.3	111.8	127.2	129.1	87.6	124.7
1973	92.1	102.7	116.1	122.8	137.1	102.2	124.1
1989	103.9	114.3	122.7	120.6	146.1	122.5	118.0
1995	104.5	121.0	125.2	121.3	144.8	122.2	116.3

Table 7 Growth in Labor Input and Hours Worked per Capita and Labor Quality

Labor Input per Capita

	US	Canada	UK	France	Germany	Italy	Japan
60-73	1.16%	1.23%	-0.48%	0.31%	-1.20%	-1.25%	1.96%
73-89	0.92%	1.23%	-0.03%	-0.82%	0.13%	1.21%	1.13%
73-95	0.88%	0.66%	0.40%	-0.41%	0.34%	0.97%	0.98%
89-95	0.78%	-0.87%	1.54%	0.68%	0.90%	0.34%	0.60%
60-89	1.02%	1.23%	-0.23%	-0.32%	-0.47%	0.11%	1.50%
60-95	0.98%	0.87%	0.07%	-0.14%	-0.23%	0.15%	1.35%

Hours worked per Capita

	US	Canada	UK	France	Germany	Italy	Japan
60-73	0.37%	0.31%	-1.01%	-0.57%	-1.53%	-1.38%	0.60%
73-89	0.56%	0.69%	-0.26%	-1.41%	-0.34%	0.86%	0.21%
73-95	0.44%	0.03%	0.01%	-1.24%	-0.16%	0.55%	0.21%
89-95	0.13%	-1.70%	0.72%	-0.79%	0.34%	-0.27%	0.21%
60-89	0.47%	0.52%	-0.60%	-1.03%	-0.87%	-0.15%	0.38%
60-95	0.42%	0.14%	-0.37%	-0.99%	-0.67%	-0.17%	0.35%

Labor Quality

	US	Canada	UK	France	Germany	Italy	Japan
60-73	0.79%	0.92%	0.53%	0.88%	0.32%	0.13%	1.36%
73-89	0.36%	0.54%	0.23%	0.58%	0.47%	0.35%	0.92%
73-95	0.44%	0.62%	0.39%	0.83%	0.50%	0.42%	0.78%
89-95	0.65%	0.84%	0.82%	1.47%	0.56%	0.62%	0.39%
60-89	0.55%	0.71%	0.37%	0.72%	0.40%	0.25%	1.12%
60-95	0.57%	0.73%	0.44%	0.85%	0.43%	0.31%	0.99%

Table 8 Levels of Labor Input and Hours Worked per Capita and Labor Quality (U.S. = 100.0 in 1985)

Labor input per Capita

	US	Canada	UK	France	Germany	Italy	Japan
1960	78.3	70.3	106.2	68.0	100.6	71.6	79.5
1973	91.0	82.4	99.8	70.8	86.0	60.8	102.6
1989	105.4	100.4	99.3	62.0	87.8	73.8	122.9
1995	110.5	95.3	108.9	64.6	92.7	75.4	127.4

Hours worked per Capita

	US	Canada	UK	France	Germany	Italy	Japan
1960	91	80	110	105	120	89	134
1973	95.5	83.7	96.6	97.4	98.7	74.6	145.3
1989	104.5	93.4	92.7	77.8	93.5	85.5	150.2
1995	105.3	84.3	96.8	74.2	95.4	84.2	152.1

Labor Quality

	US	Canada	UK	France	Germany	Italy	Japan
1960	86.0	87.4	96.4	64.8	83.6	80.3	59.2
1973	95.3	98.5	103.2	72.6	87.2	81.6	70.6
1989	100.9	107.5	107.1	79.7	94.0	86.3	81.8
1995	104.9	113.0	112.5	87.1	97.2	89.6	83.7

Figure 1a
Sources of Output Growth 1960-1973

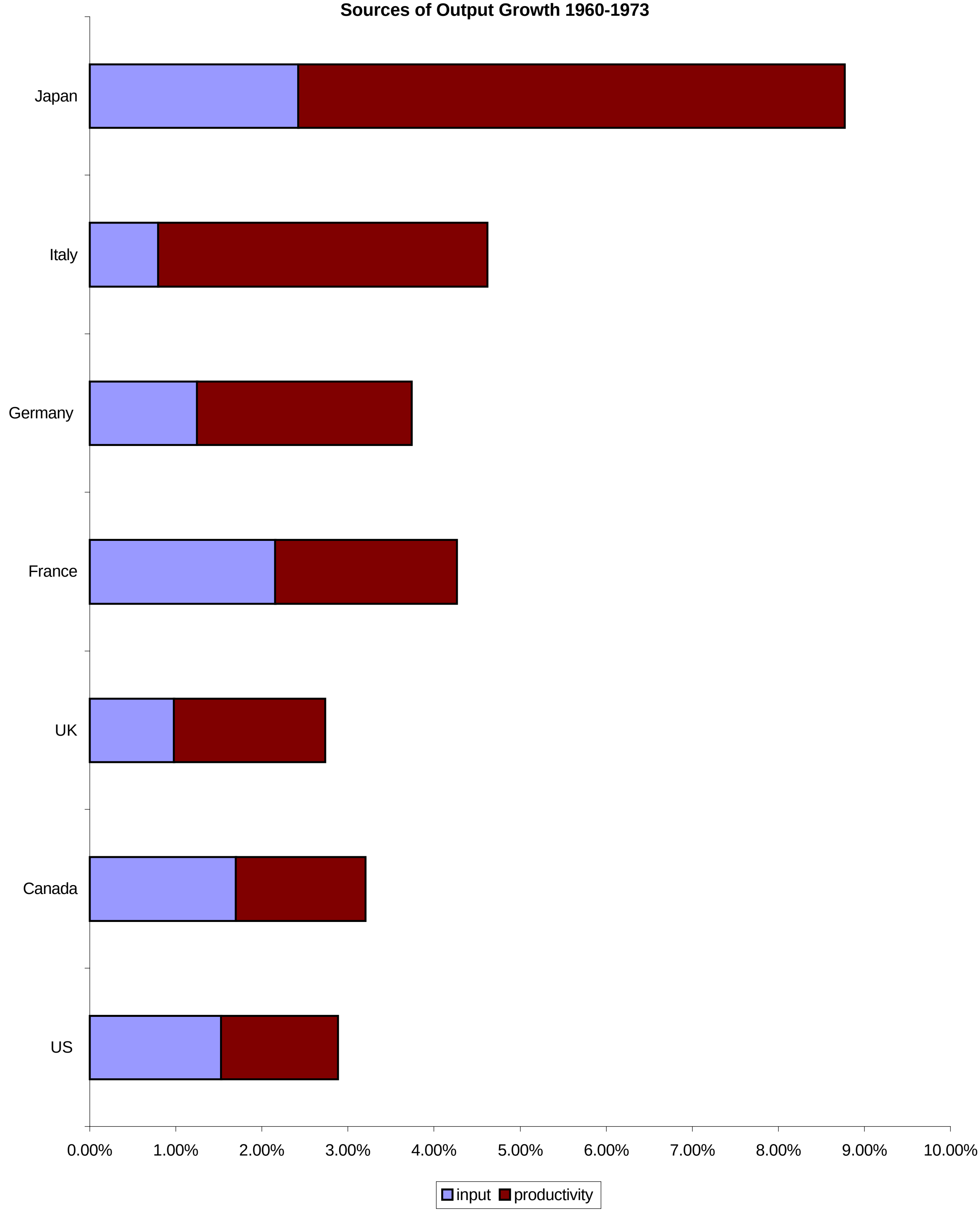


Figure 1b
Sources of Output Growth 1973-1989

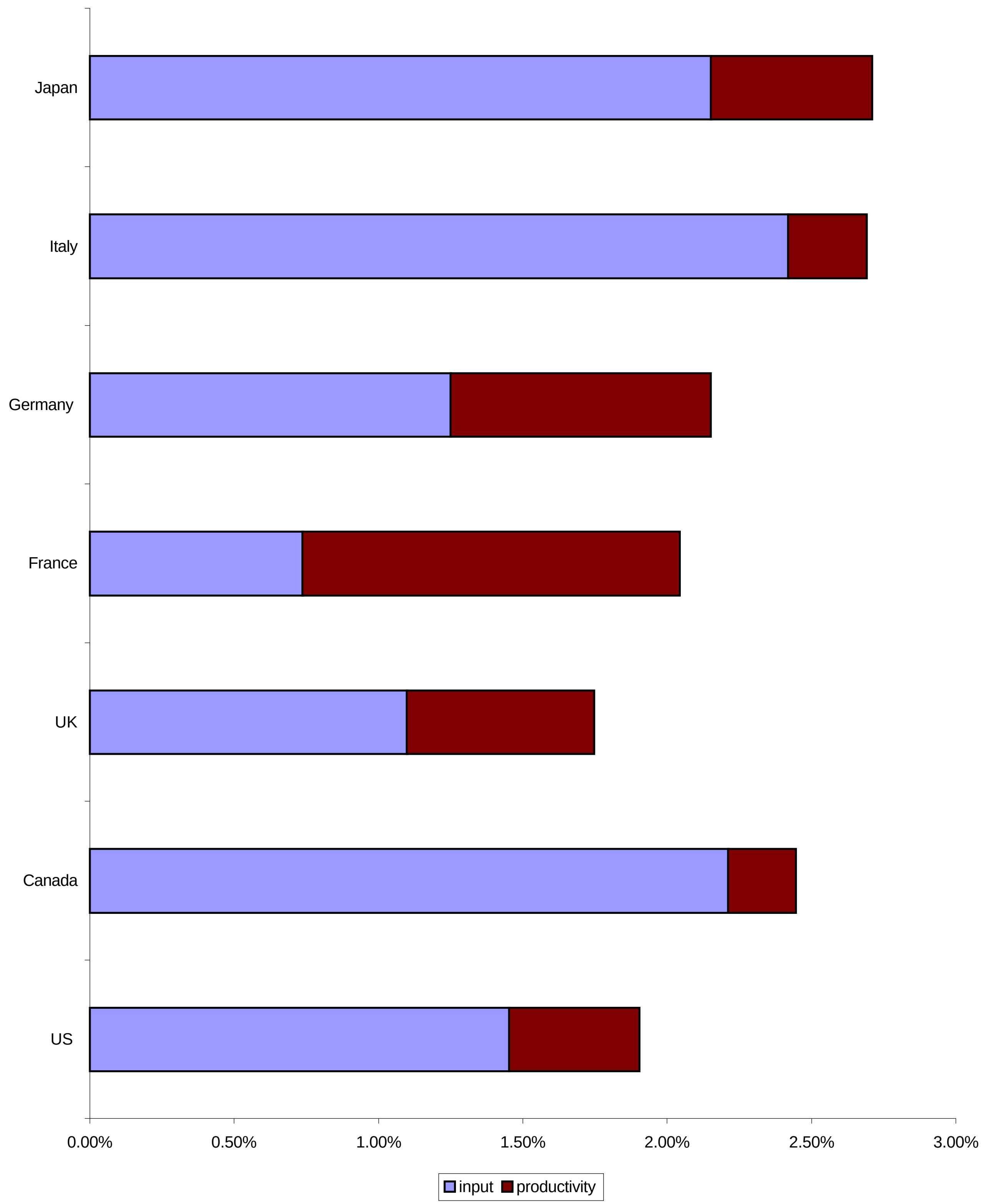


Figure 1c
Source of Output Growth 1960 - 1989

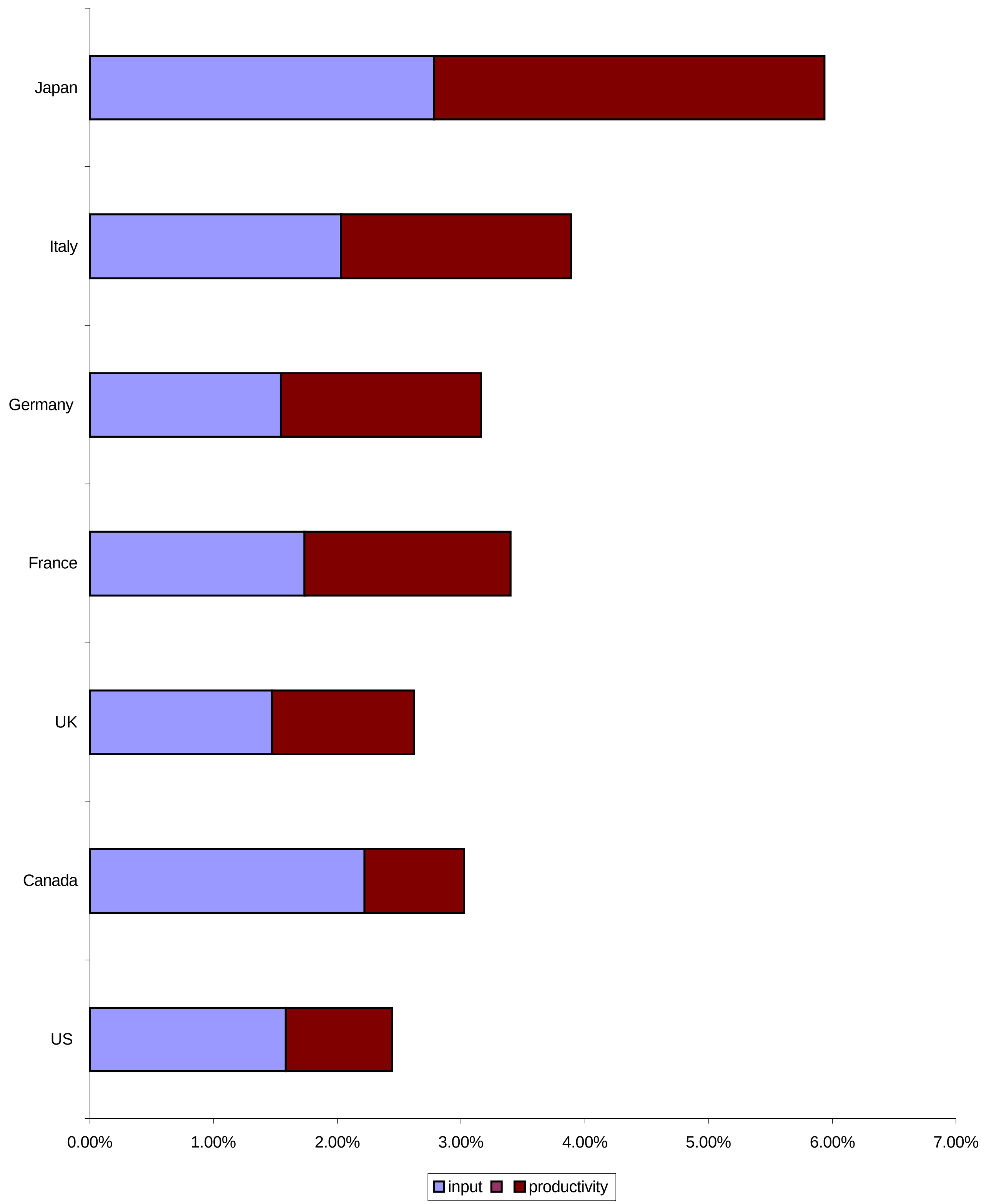


Figure 1d
Sources of Output Growth 1989-1995

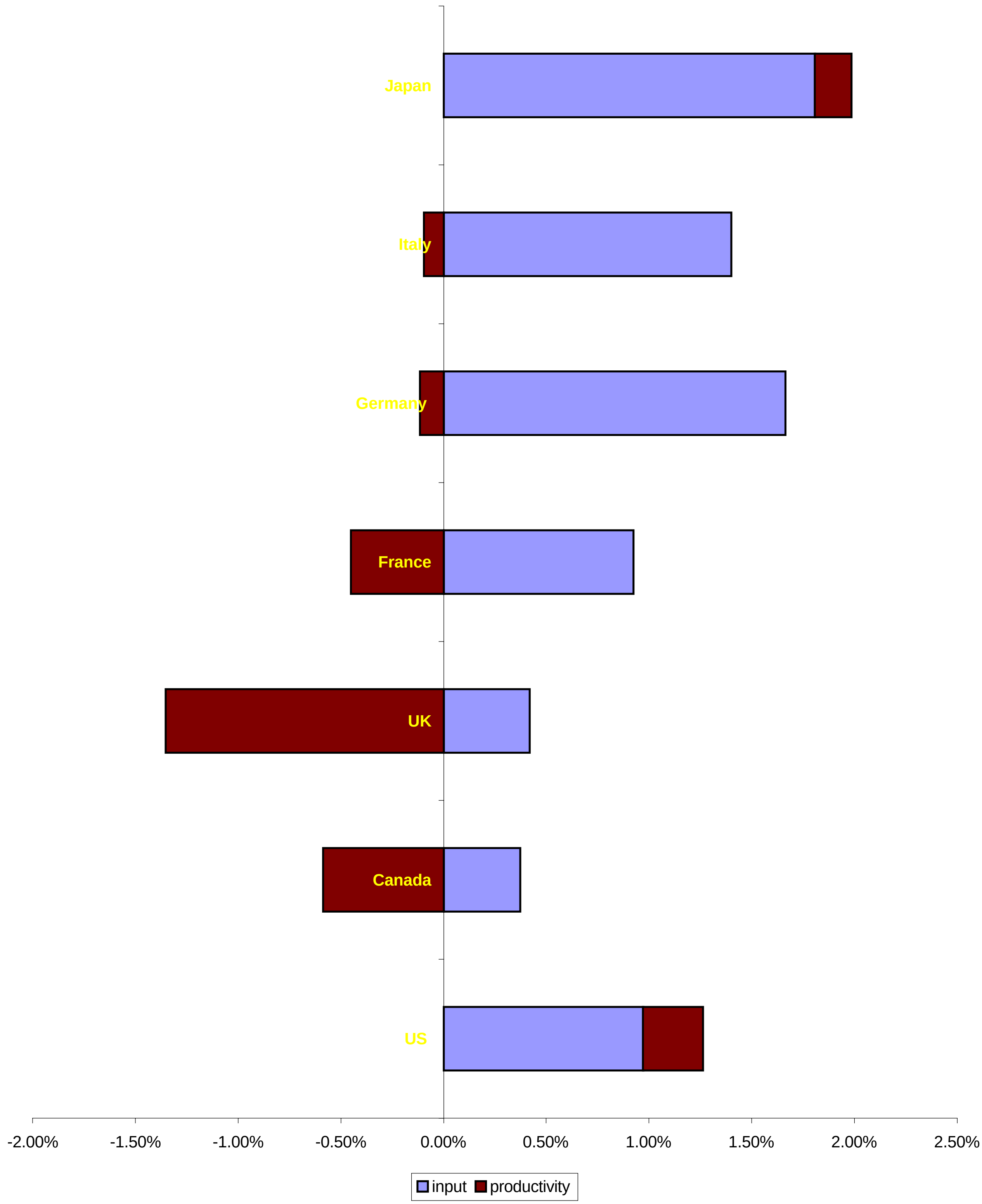


Figure 1e
Sources of Output Growth 1960-1995

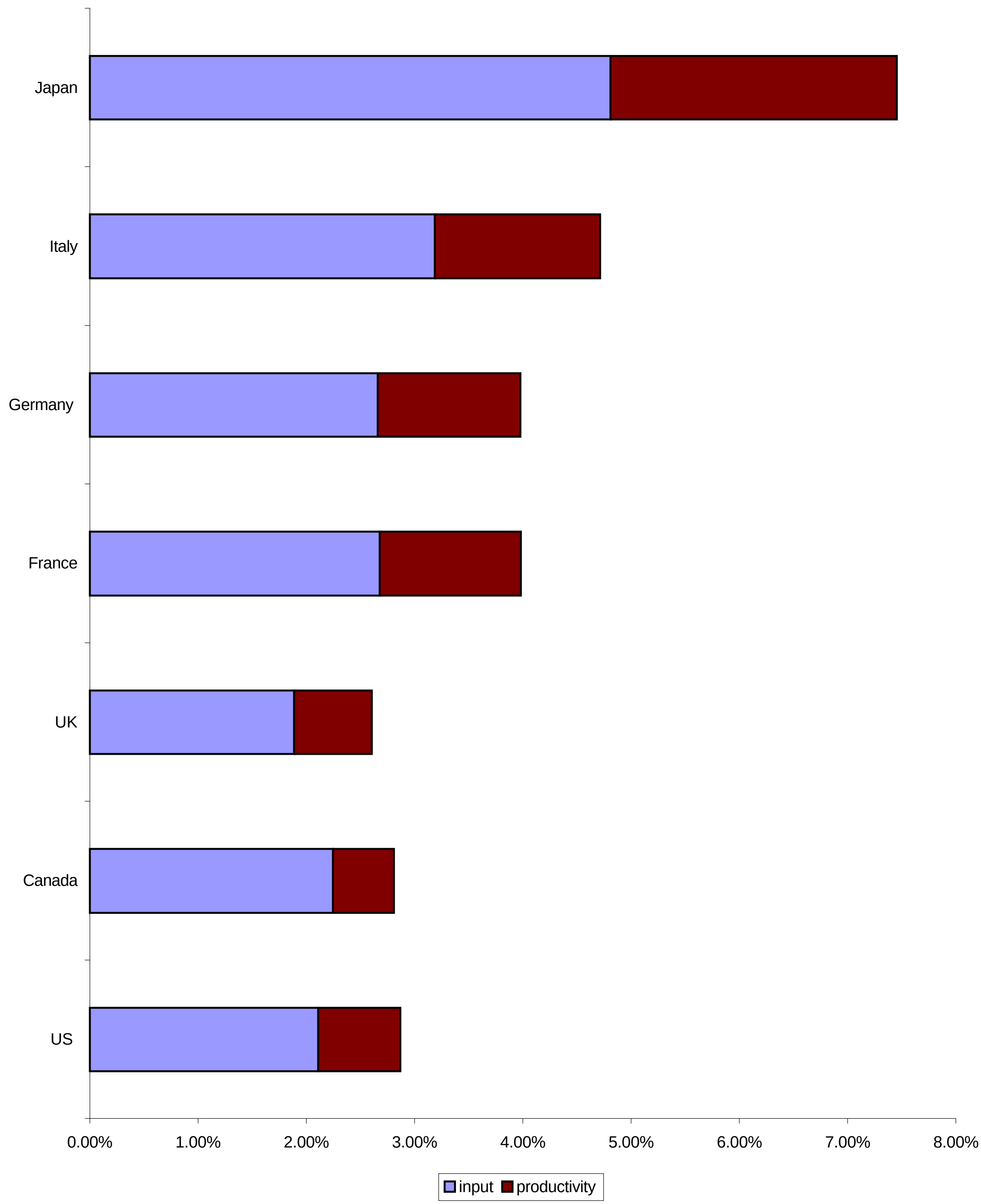


Figure 1f
Sources of Output Growth 1973-1995

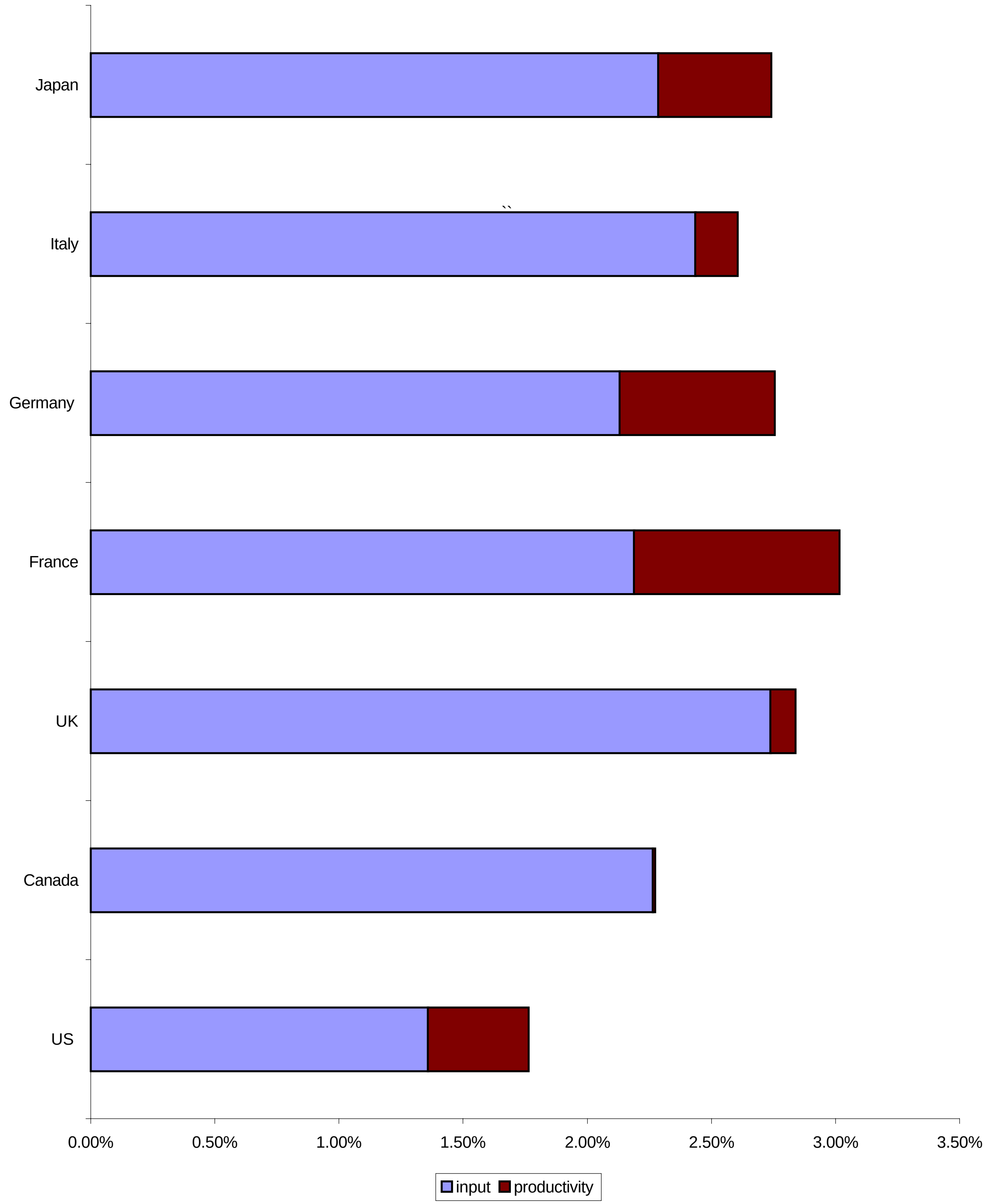


Figure 2a
Sources of Capital Input Growth 1960-1973

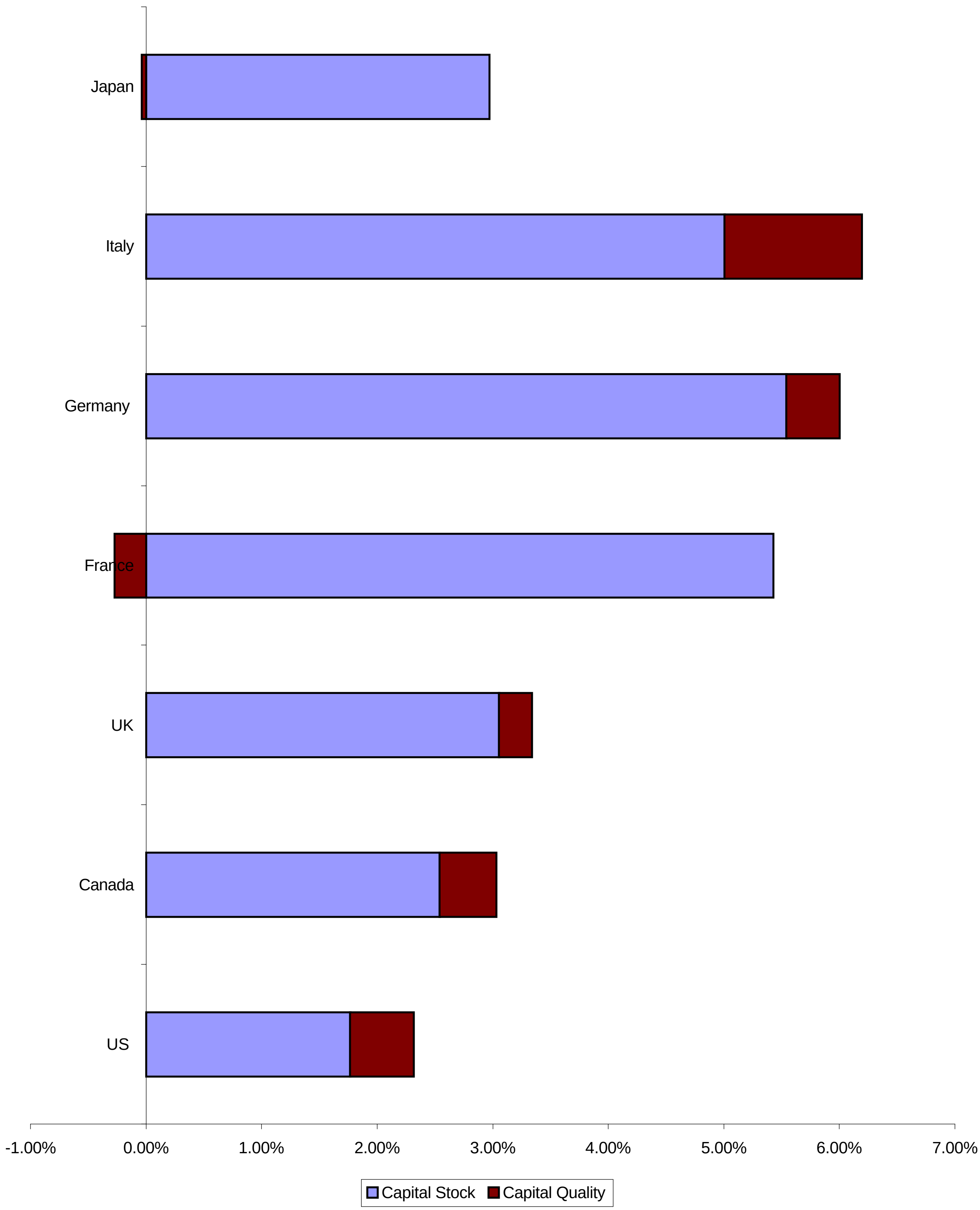
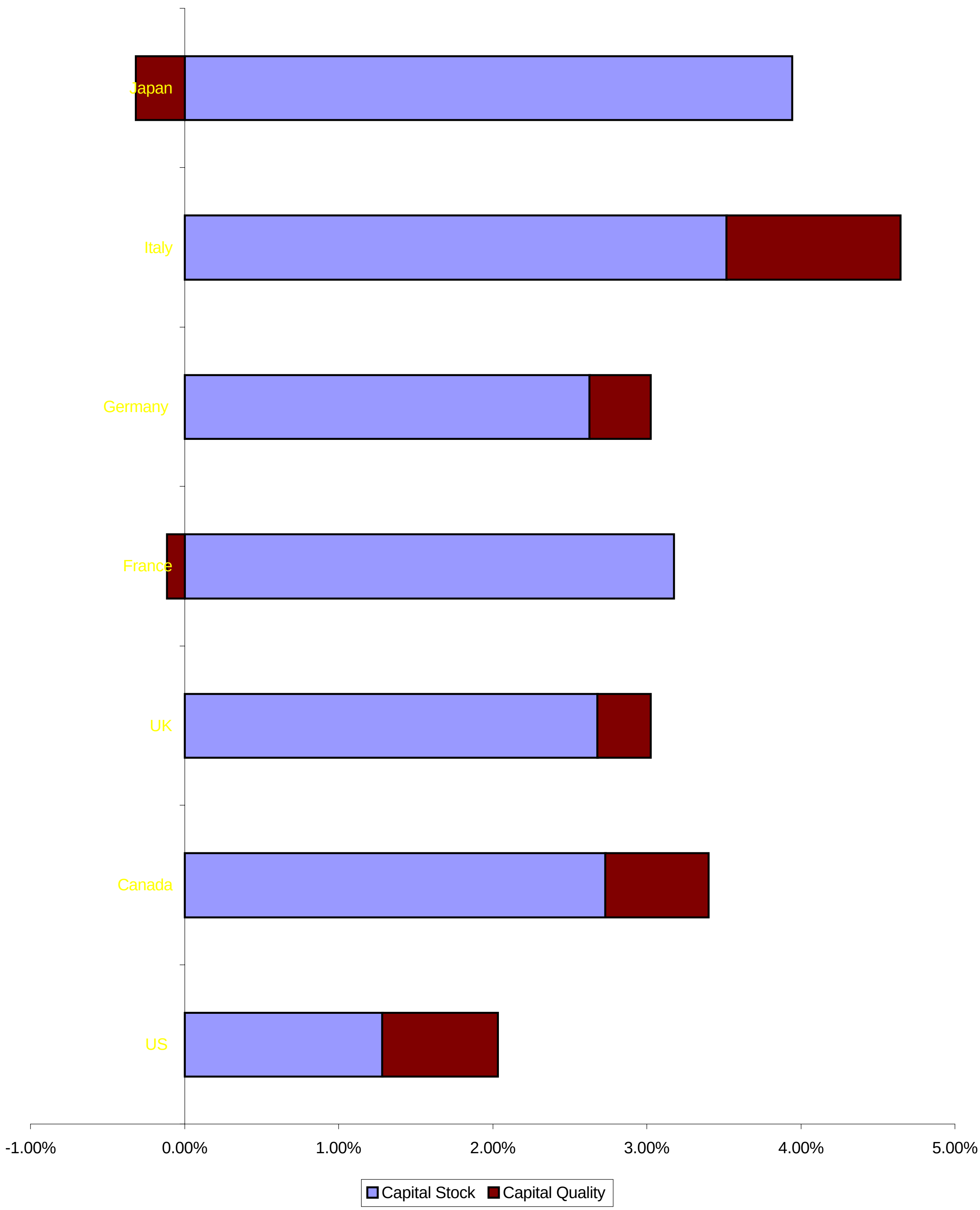


Figure 2b
Source of Capital Input Growth 1973-1989



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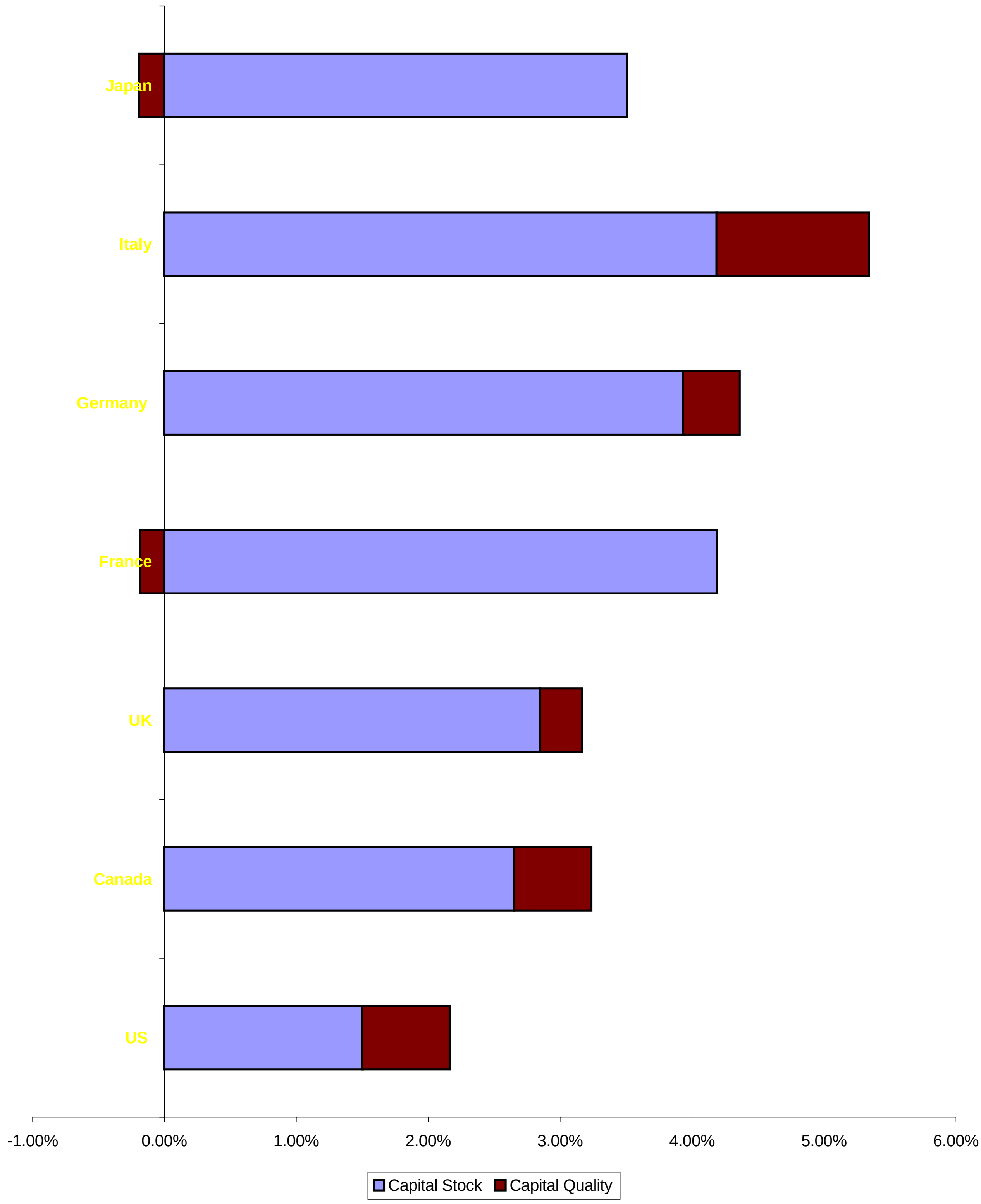

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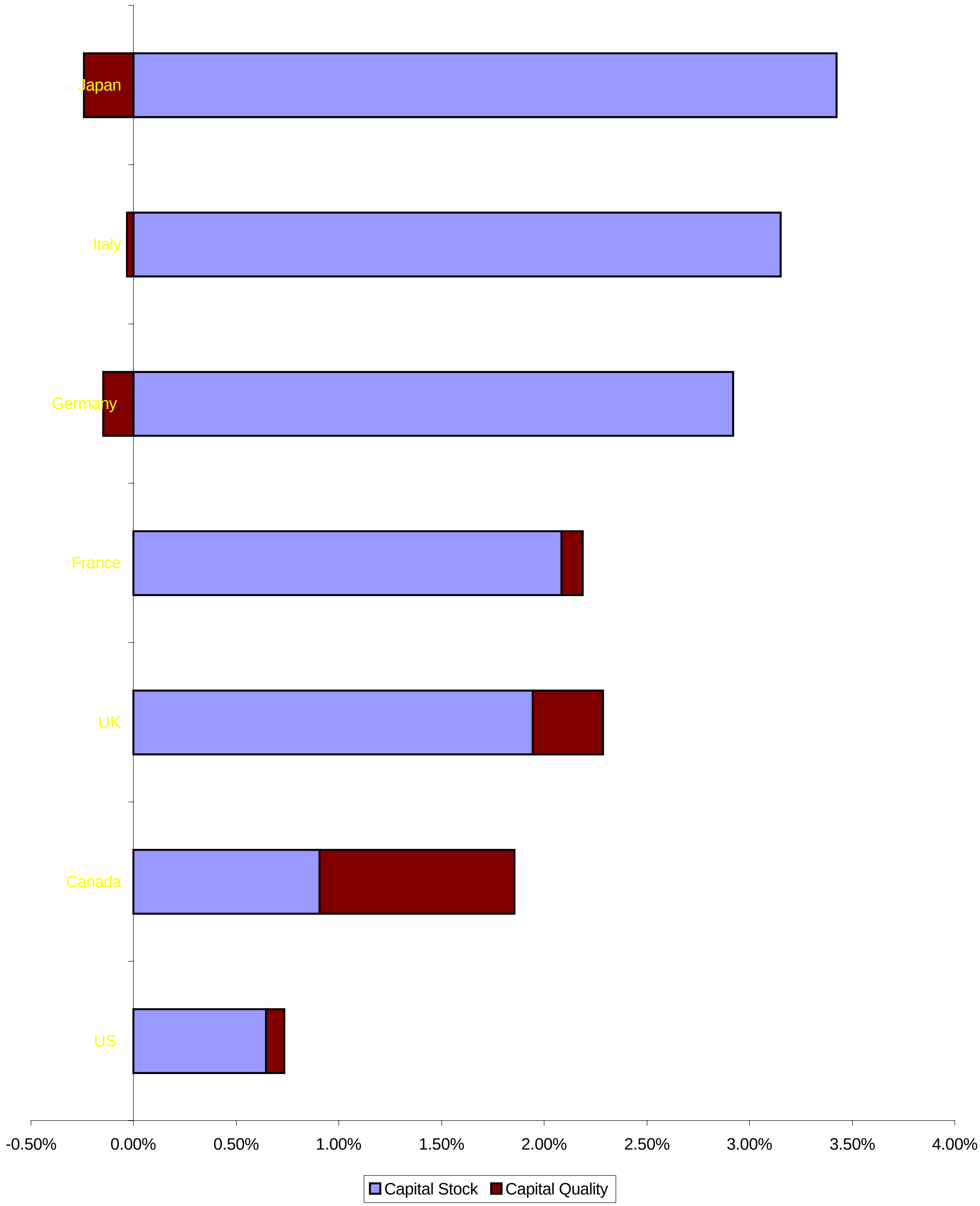

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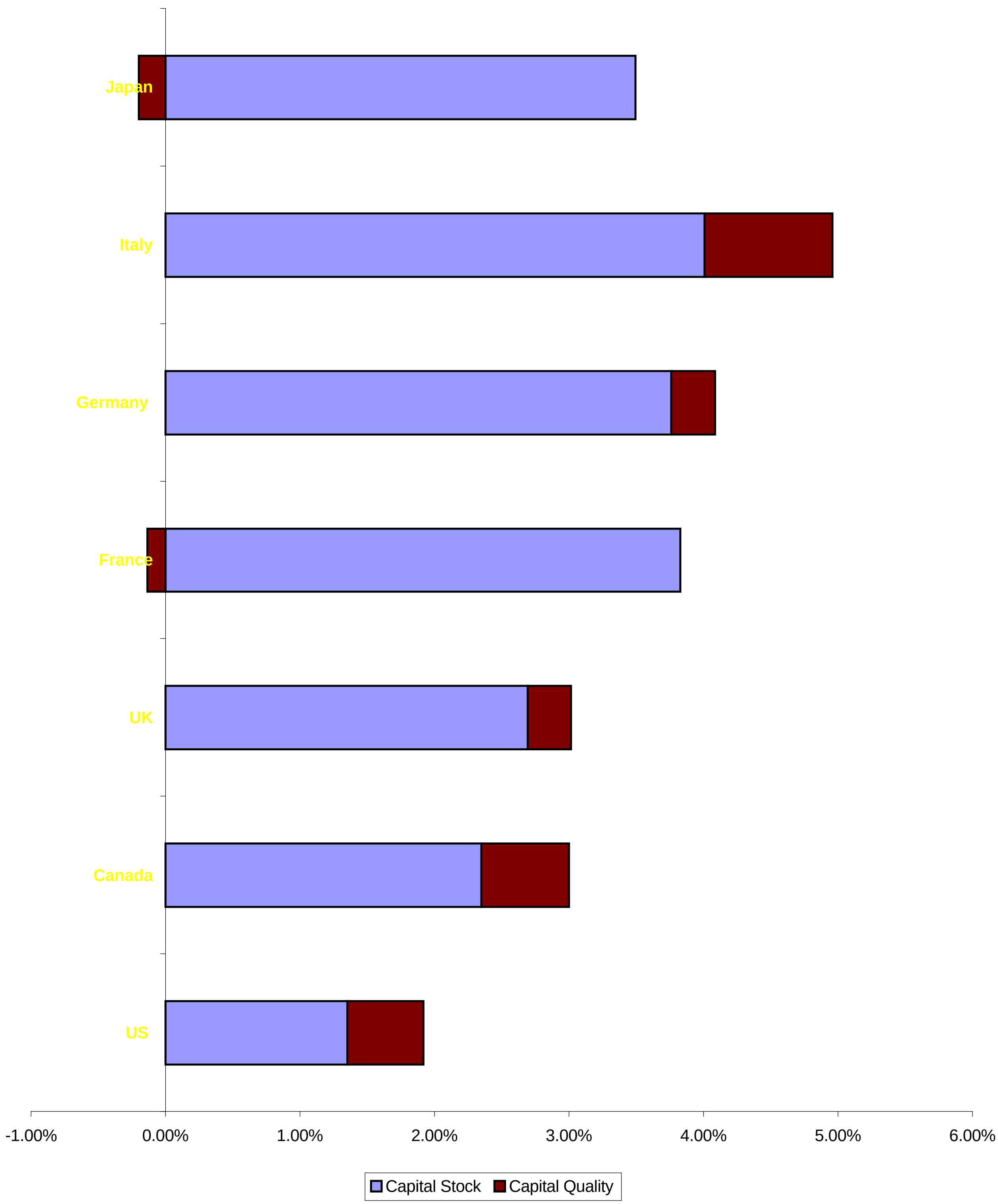

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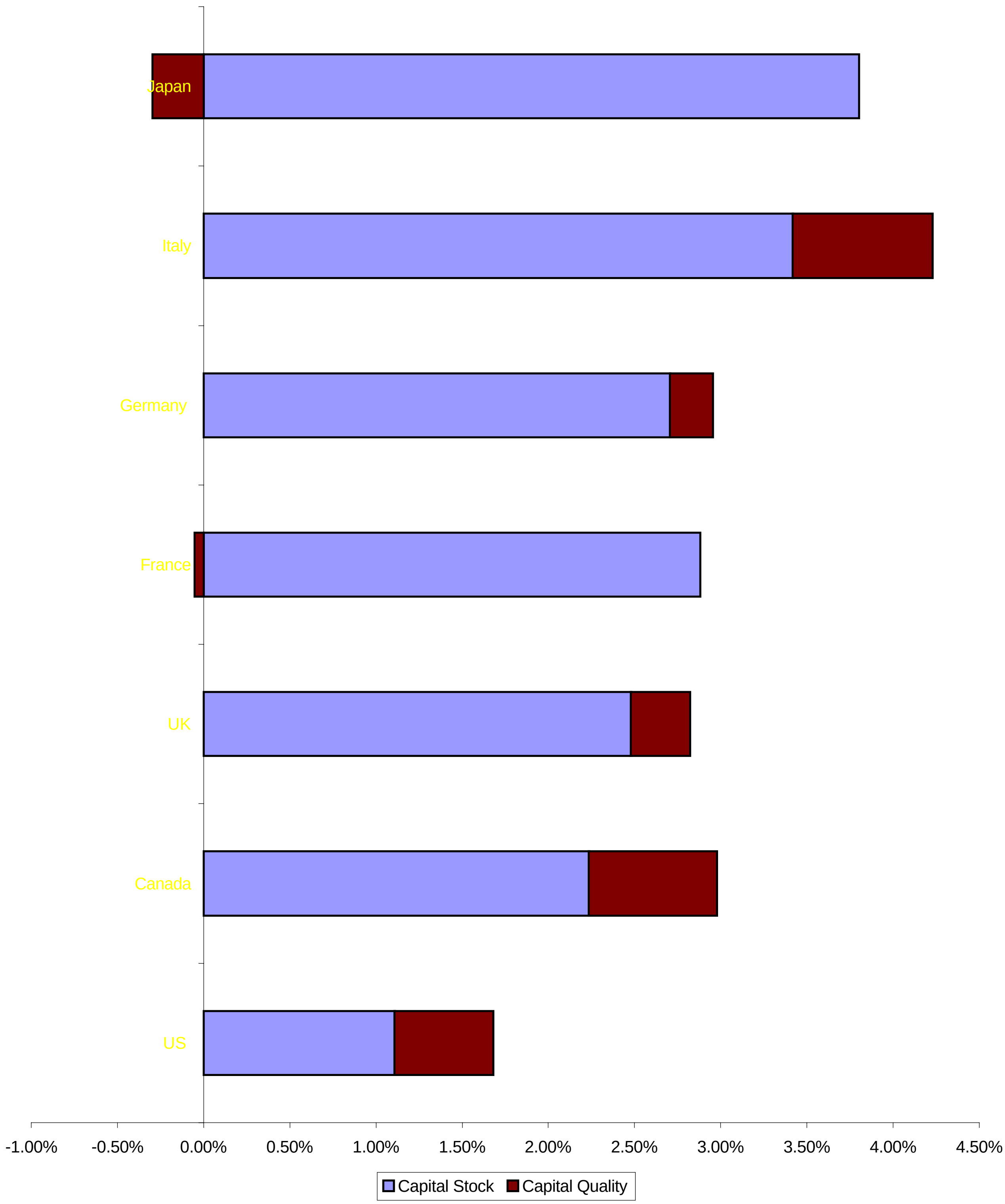

Figure 3a
Sources of Labor Input Growth 1960-1973

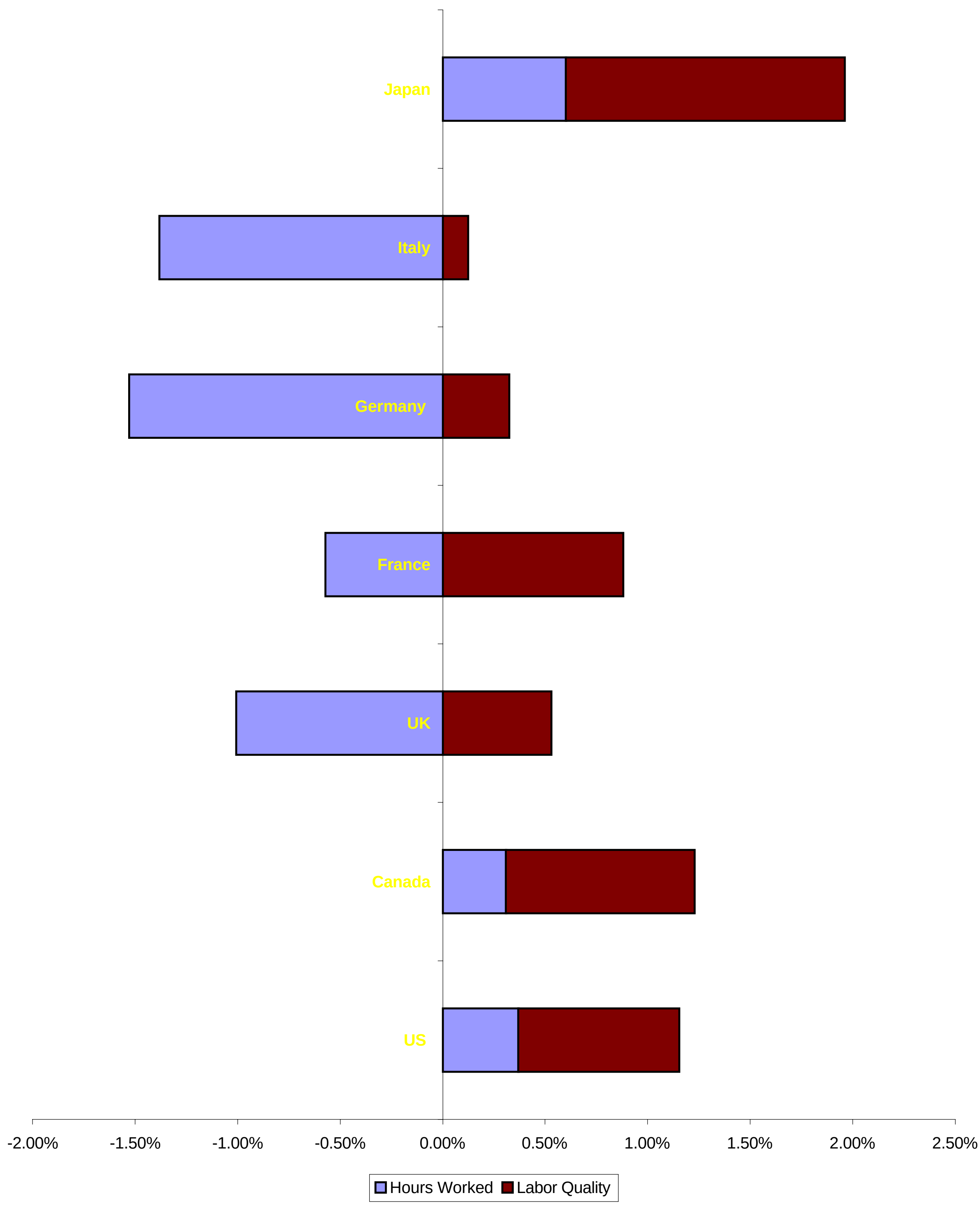

Figure 3b
Sources of Labor Input Growth 1973-1989

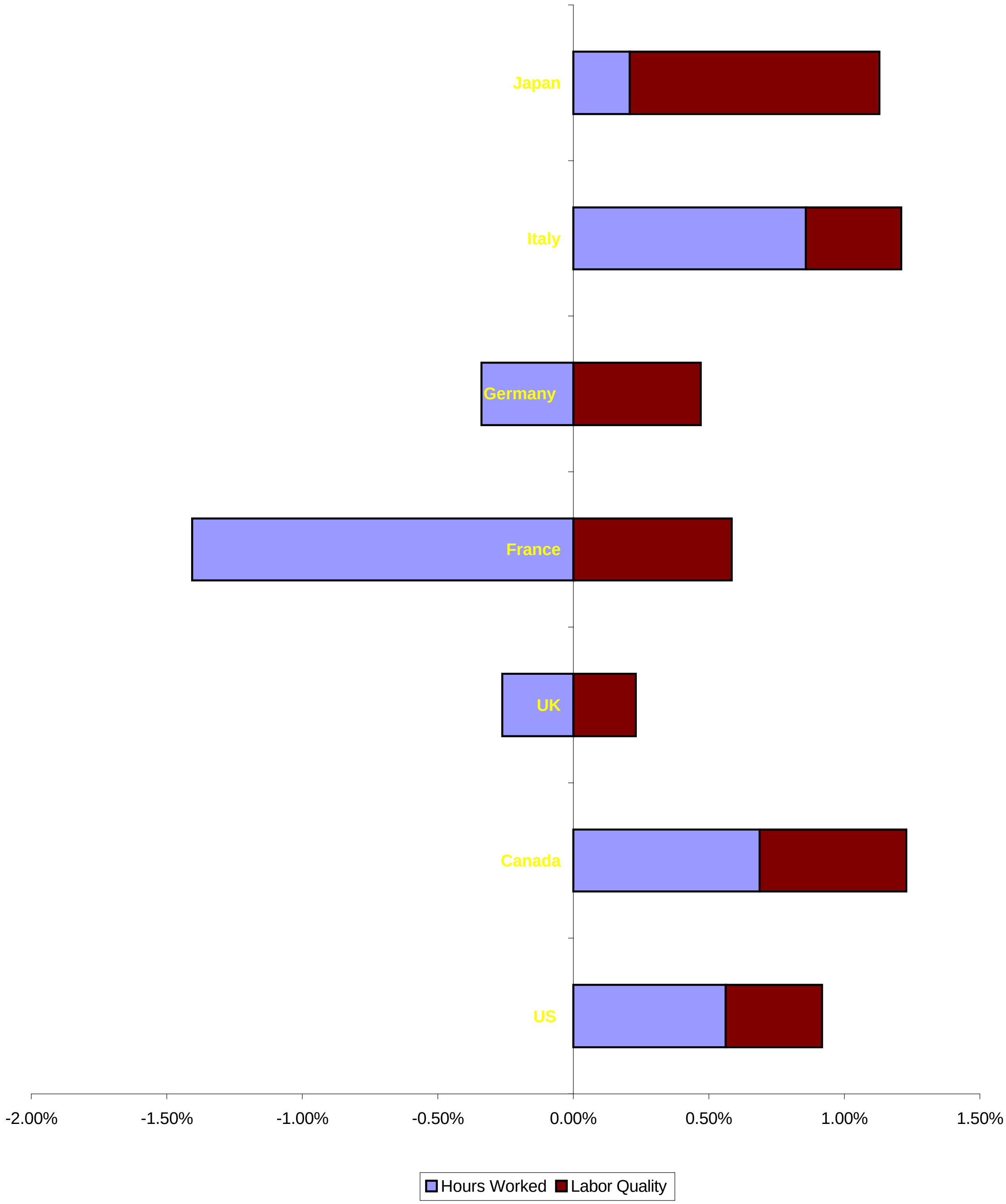

Figure 3c
Sources of Labor Input Growth 1960-1989

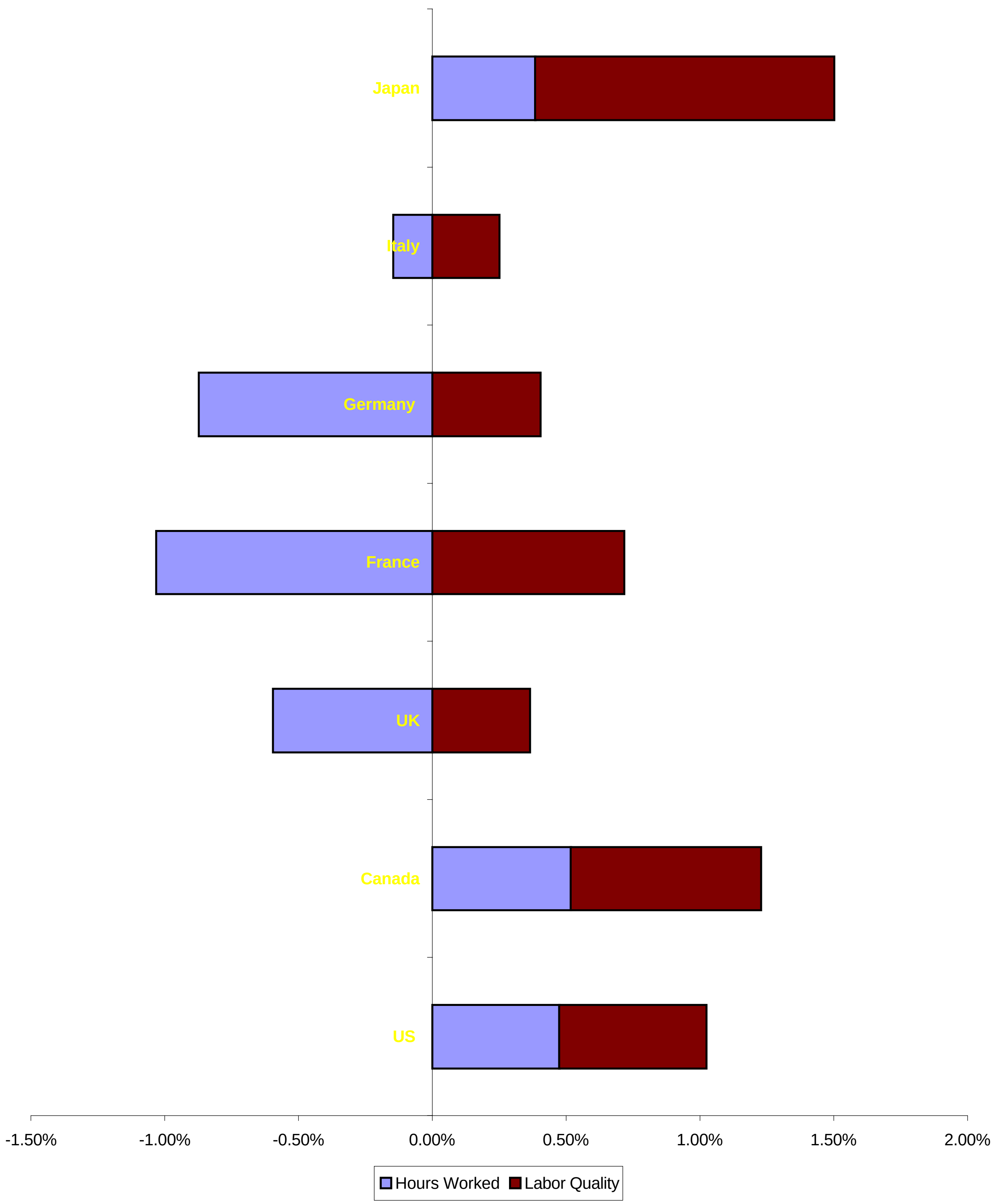

Figure 3d
Sources of Labor Input Growth 1989-1995

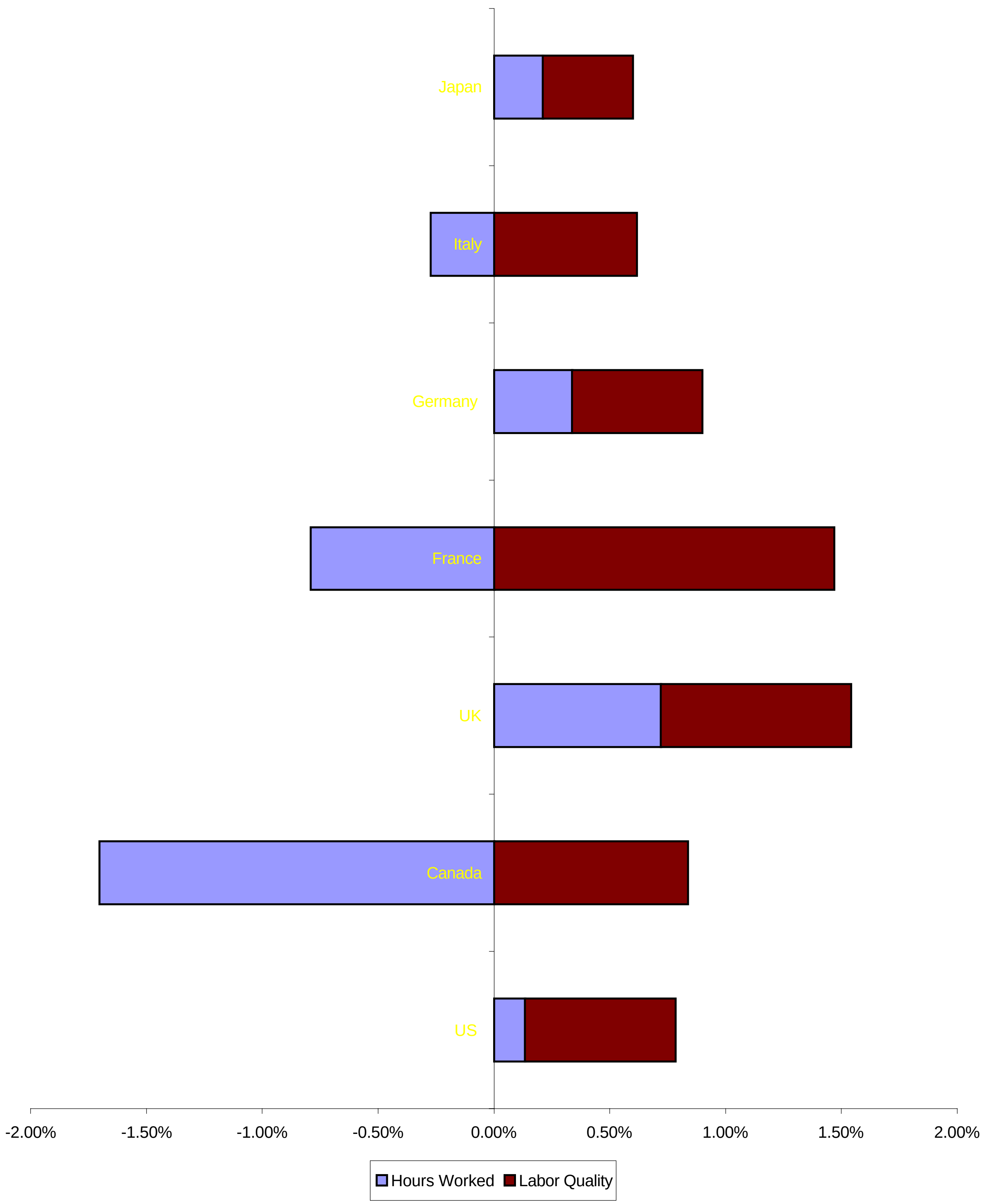

Figure 3e
Sources of Labor Input Growth 1960-1995

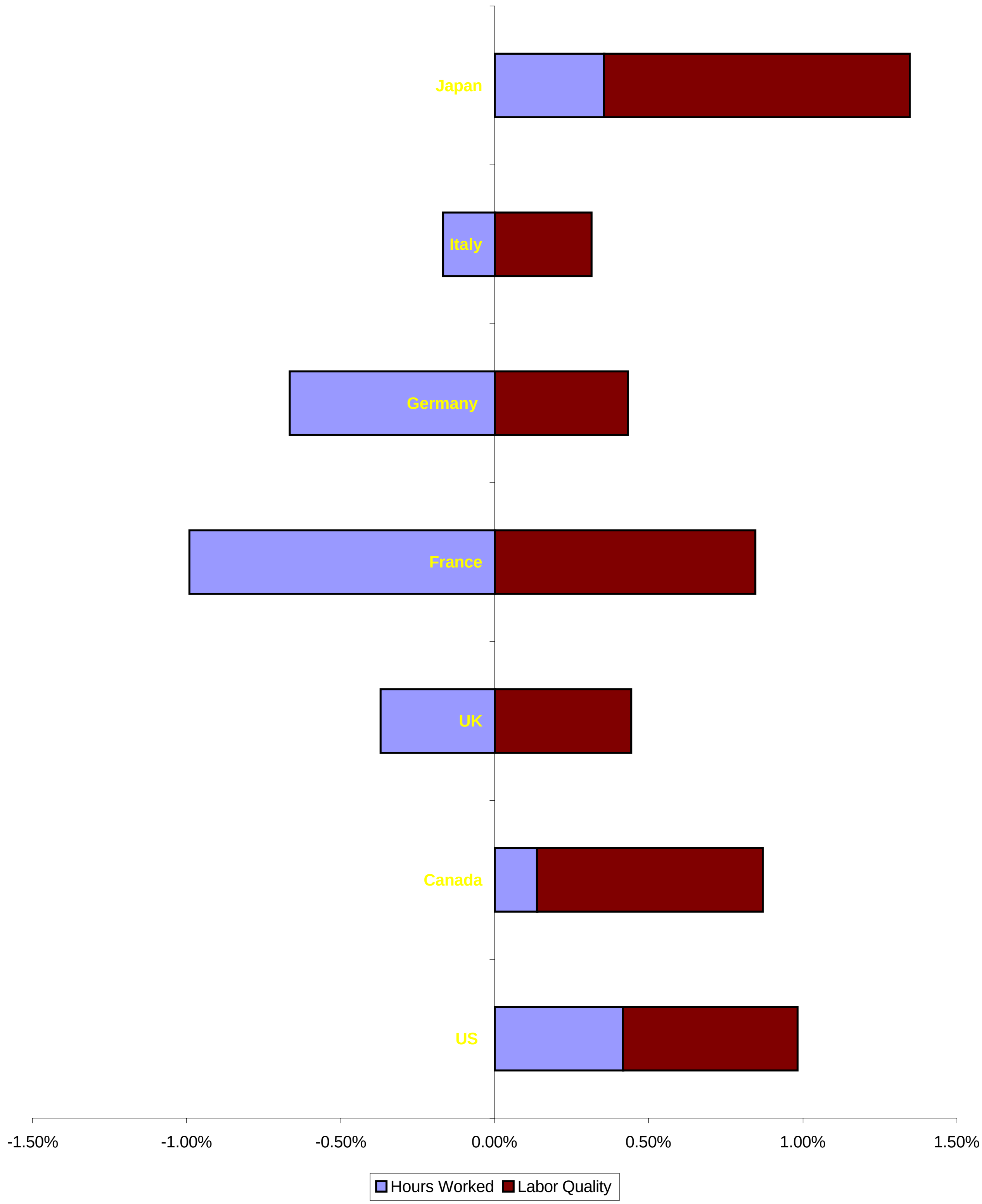

Figure 3f
Sources of Labor Input Growth 1973-1995

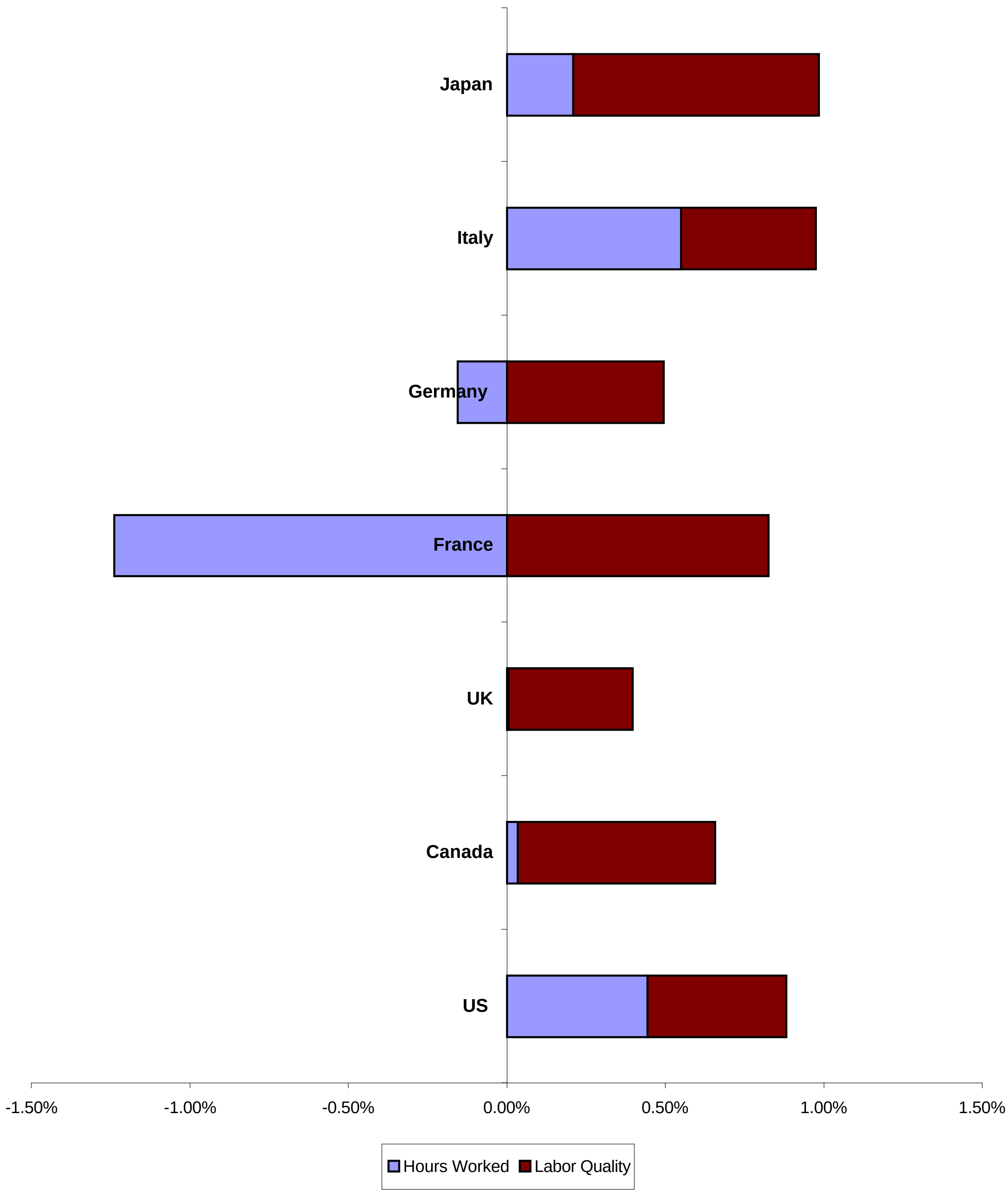

Figure 4
Convergence of Output and Input per Capita and Productivity

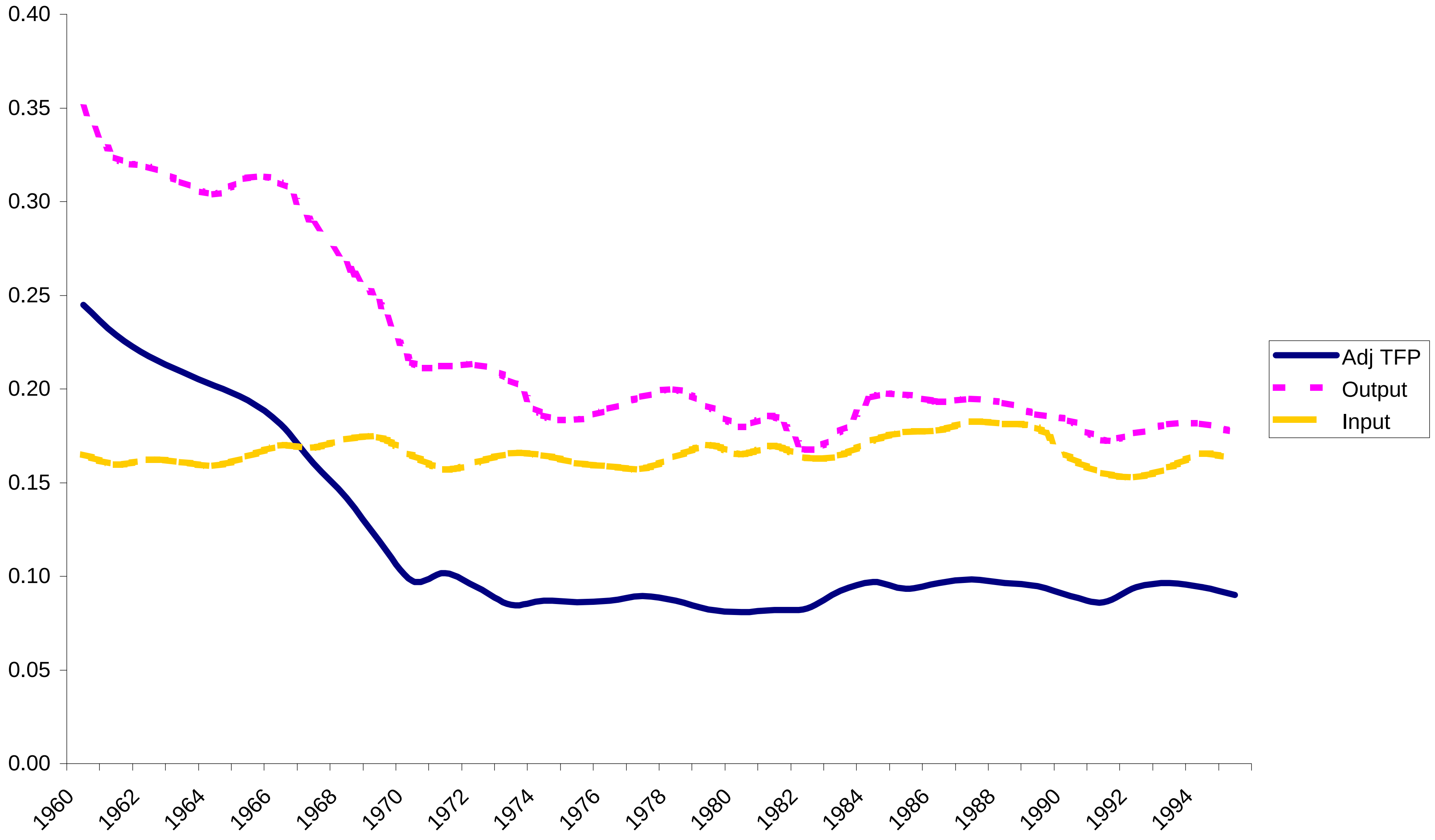

Figure 5
Convergence of Capital Input, Capital Stock per Capita and Capital Quality

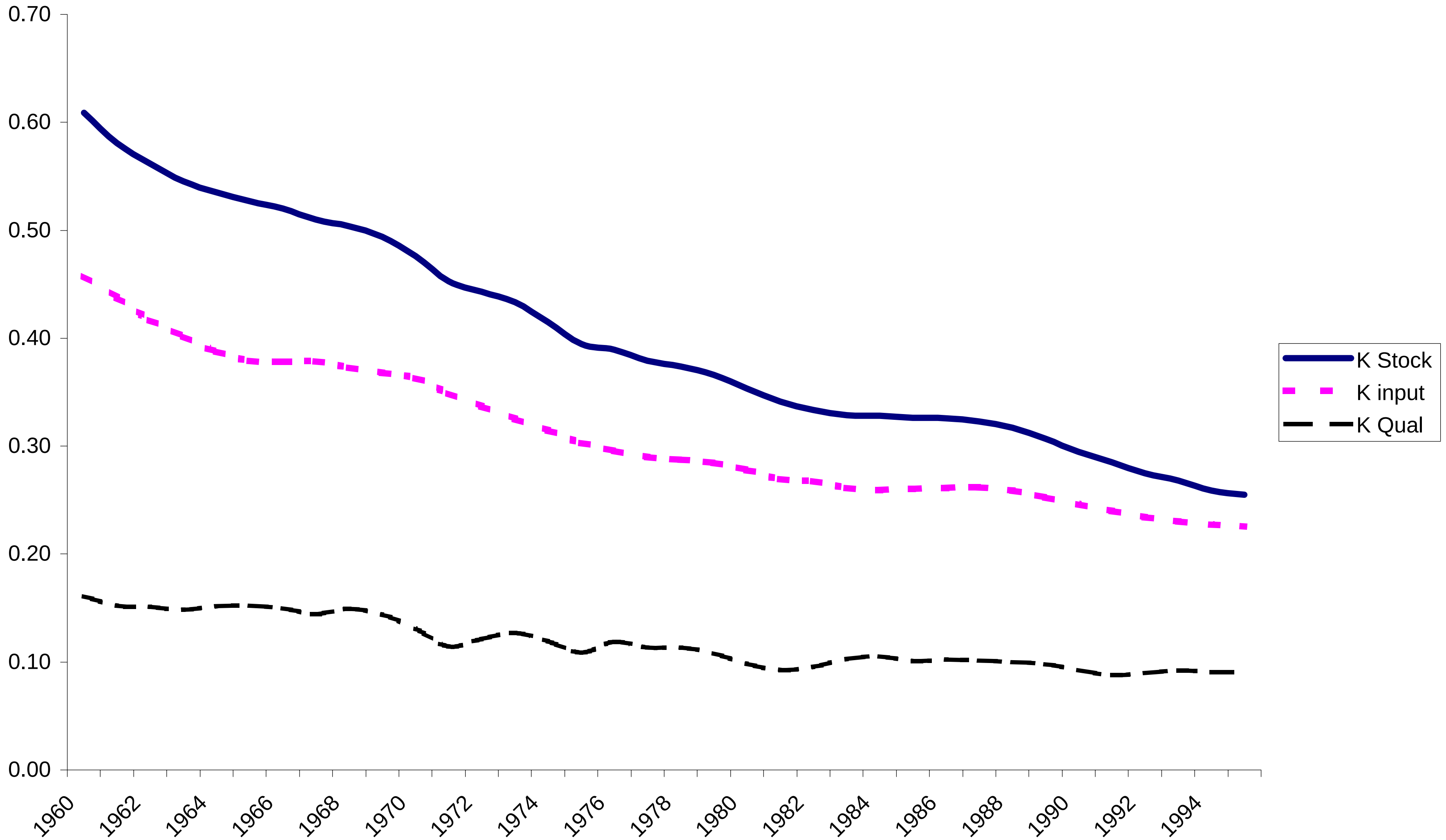

Figure 6
Convergence of Labor Input and Hours Worked
per Capita and Labor Quality