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Measuring Real Investment: Trends in the United States and International Comparisons

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In the early 1970s, according to the standard OECD national accounts data, U.S. capital formation was about 19 percent of GDP while in the other main developed countries it was, on average, a quarter of their GDPs—an investment ratio nearly one-third higher. In 1990-1994, the ratios were closer, but the other developed countries were still investing at a rate about 23 percent greater than that of the United States. That apparently low rate of U.S. capital formation and its presumed effect on U.S. economic growth were noted with alarm in some of the Economic Reports of the President and in many other projections of U.S. economic prospects. During the first half of the period after 1970, U.S. real income per capita *did* grow more slowly than that of other developed countries, but in the second half, despite the higher investment rates in other countries, it remained more than a third higher than the OECD average and more than a half above the average for OECD-Europe. The apparent absence of large relative growth consequences of these low relative U.S. investment rates suggests that a careful look at the measures of investment rates may be in order.

In this paper we point out the importance of price trends and differences in price levels for real investment rates and also the consequences of accepting conventional measures of capital formation, the boundaries of which have more to do with the wide availability of data than with what economists define as "investment" or "capital formation."

"Conventional" measures of investment—those imbedded in national income and product accounts—treat only physical capital investment as investment, or capital formation; these are business and nonmilitary government construction and purchases of plant and equipment, and purchases of owner-occupied housing. That has been the case despite a long tradition of theoretical arguments for broader concepts, going back at least over 100 years to Alfred Marshall's *Principles of Economics* (1890), and including the development of human capital theory in the work of Friedman and Kuznets (1945), Becker (1964), Mincer (1974), Schultz (1970), and many others. The use of conventional measures also ignores the alternative measures, developed by Kendrick (1976), Eisner (1989), and others. The most radical of these measures, by Jorgenson and Fraumeni (1989), suggests that the conventionally defined capital formation, to which we give such attention, is almost trivial, accounting for only about 5 percent of a broadly conceived measure.

We have concentrated on the ratios of capital formation to GDP, rather than saving to GDP. If a country is receiving large inflows of capital from abroad or investing heavily in foreign countries, the two ratios could be quite different. Since the United States, for example, has been running a substantial current account deficit in the balance of payments for many years, the saving ratio must be lower than the capital-formation ratio, although it may not be lower relative to the average of other countries. The conceptual changes in the scope of capital formation used in this paper imply corresponding changes in

measures of saving, because items conventionally classified as consumption are removed from that category. These include household and government current expenditures on education, government and business expenditures on research and development, household expenditures on durable equipment, and government expenditures on military capital formation. Their removal from the consumption category would raise levels of saving.

The conventional comparisons of capital formation across countries are not only narrow in scope; they also ignore the implications of large differences in the prices of capital goods, and in prices of capital goods relative to prices of goods in general, from one country to another. The effect of these differences is that a given nominal amount of capital formation in one country can yield considerably more real physical or human capital and more relative to real GDP than the same nominal amount in another country. In a similar way, comparisons over time of nominal investment ratios in individual countries ignore trends in relative prices of capital goods and output in general. A stable ratio of nominal capital formation to nominal output could represent a rising or falling trend in the contribution of capital formation to growth.

Over the last decade, there has been a revival of interest in research that focuses on understanding and explaining the sources of long-term economic growth. Some of the new approaches that seek to overcome the limitations of the traditional neoclassical growth model emphasize redefining capital as a broader measure that includes not only physical capital but also other types of reproducible intangible capital, such as human capital and the state of knowledge. Barro (1991), Mankiw, Romer, and Weil (1992), and Nonneman and Vannhoudt (1996) have carried out empirical studies employing the broader concepts of capital accumulation to explain economic growth. They indicate that adding nonconventional elements to the measures of capital formation substantially improves the ability to explain rates of growth. These studies necessarily rely on crude proxies for most of the additions to conventional capital formation because they cover large numbers of countries. We hope we can do better on the measurement side for the developed countries studied here, but we leave the possible connection with economic growth for later research.[1]

THE CONVENTIONAL COMPARISON OF CAPITAL FORMATION

The conventional story of U.S. investment in comparison with that of other developed countries is shown in Table 1. The United States has persistently invested less of its GDP, in nominal terms, than the average of the other 12 OECD countries we examine here. From the early 1970s to the early 1980s, the relative proportion of U.S. investment drew closer to that of the other countries, but the ratio then declined through the early 1990s.

The changes in the relative investment ratios during the 1970s and early 1980s were not primarily the result of any major shift toward higher investment in the United States. Rather, average nominal investment ratios in the other 12 countries fell from 25 percent in 1970-74 to 20 percent in 1990-94—a decline of 20 percent—while the U.S. ratio stayed around 19 percent until it dropped in the latest period to about 16 percent. At the end of the period, the United States ranked eighth among the 13 countries covered here, below Belgium, Canada, France, Germany, Japan, Netherlands, and Norway. Thus, in terms of the conventional measure of "investment effort" or the sacrifice of current consumption for future growth, the United States appears to have remained somewhat of a spendthrift relative to other developed countries, more of a grasshopper than an ant.

THE PRICE OF CAPITAL GOODS AND REAL CAPITAL FORMATION

The ratio of capital formation to total output, however capital formation is defined, reflects both the country's willing-

[1] For an earlier study of roughly the first half of the period, covering fewer countries, see Lipsey and Kravis (1987), Chapter 2.

ness to sacrifice present consumption for growth and future consumption, and the willingness of other countries to invest their capital there. That ratio does not indicate how much capital is being acquired or how much is being acquired relative to output, because it does not take account of the price of capital goods, relative to the price of other goods and services. That relative price varies over time in any one country, and it varies considerably across countries. In a single country over time, if the price of capital goods is falling relative to other prices, a constant nominal ratio of capital formation to total output would mean a rising real capital-formation ratio, possibly producing accelerating growth or offsetting decreasing returns to capital. Similarly, if country A and country B have the same total output and the same ratio of capital formation to total output, but country A has a price of capital goods relative to total output half as high as that of country B, country A should enjoy twice as great an impact from its capital formation. Whatever influence capital formation has on future growth should be correspondingly greater.

We estimate real capital formation and real capital-formation ratios across countries here by making use of estimates of purchasing power parities for capital goods and for output in general from the United Nations' International Comparison Program (ICP) and derivatives from that program calculated for intervening years by the OECD and by Summers and Heston (1991).[2] The purchasing power parities, in combination with market exchange rates, give us prices for capital goods and GDP as a whole.

Trends in real capital-formation ratios from 1970 to 1994 were affected by changes over time in the relation of capital-formation prices to prices in general. In the United States, for example, the price of capital formation rose about 7 percent relative to that of GDP from 1970 through 1981. Then it began to fall in relative terms, until by 1994 it had reached 20 percent below the 1970 level (Figure 1). This trend in relative prices implies that after 1981 the U.S. capital-formation ratio in constant 1970 prices rose relative to that in current prices. In Table 2, the real capital-formation ratios for the United States, in 1970 prices, are compared with the ones in current prices. The most striking difference between trends of capital-formation ratios in nominal terms and trends in real terms is that the large decline in the nominal ratios between 1980-84 and 1985-89 and the even larger one between 1985-89 and 1990-94 disappear completely when capital formation is measured in constant prices. The U.S. capital-formation ratio in real terms shows increases in both periods,

Table 1

U.S. Nominal Gross Fixed Capital Formation As a Percent of Nominal GDP Relative to 12 Other OECD Countries†

	Percent
1970-74	75.3
1975-79	81.6
1980-84	90.6
1985-90	87.6
1991-94	83.2

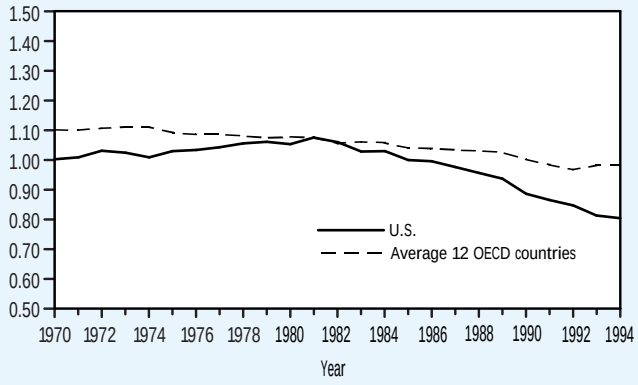
SOURCE: Kirova and Lipsey (1997), Appendix B, Table B-1.

†Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, Netherlands, Norway, Sweden, and the U.K.. The list was determined by the availability of data.

Figure 1

Ratio of Capital Formation Price to GDP Price

(U.S. 1970 = 1)



[2] The program and its methods are described, for the earlier years, in Kravis, Kenessey, Heston, and Summers (1975) and Kravis, Heston, and Summers (1978 and 1982). For a description of later developments see Kravis and Lipsey (1991).

Table 2

Ratios of Conventional Capital Formation to GDP for the United States

	Current Prices	1970 Prices
1970-74	18.8	18.6
1975-79	19.3	18.5
1980-84	19.3	18.4
1985-89	18.6	19.1
1990-94	16.3	19.4

SOURCE: Kirova and Lipsey (1997), Appendix B, Table B-1.

Table 3

Average Ratios of Conventional Capital Formation to GDP for 12 OECD Countries Other than the United States

	Current National Prices	PPPs and 1970 World Prices
1970-74	25.0	22.7
1975-79	23.8	22.0
1980-84	21.3	20.1
1985-89	21.3	20.6
1990-94	19.7	20.1

SOURCE: Kirova and Lipsey (1997), Appendix B, Table B-1.

adding up to about a 5 percent increase in the last decade.

We can compare capital-formation ratios in the United States with capital-formation ratios in other countries by using price-level measures based on world prices. For example, if two countries had the same level of real GDP, measured at world prices, and the same real ratios of capital formation to GDP, they would have the same real capital formation—that is, they would have the same amounts of additions to their capital stocks in physical terms. Investment goods, conventionally defined, were generally cheaper in the United States than in other countries over the period 1970-94, as might be expected from the fact that the United States has had a comparative trade advantage in capital equipment. Therefore, the United States gets more real capital formation per unit of consumption foregone than other developed countries do.

Conventional capital goods were cheaper in the United States than in the other 12 OECD countries in every period, but the differential has varied over time. The price of capital goods in the other 12 countries was falling relative to that of GDP throughout the entire period 1970-94, but not as much as in the United States (Figure 1). The differential between relative prices in the United States and in the other 12 countries has been rising steadily since the beginning of the 1980s. The price of capital goods relative to that for all goods and services has fallen in the United States by more than 10 percent as compared with relative prices in the other countries, mainly because of the rapid fall in relative prices in the United States after 1981.

We calculate real capital-formation ratios that are comparable over time and across countries for the other 12 OECD countries by using constant world prices for capital formation and GDP. The real capital-formation ratios for the 12 OECD countries implied by the use of PPPs and constant world prices are compared with the ones in current own-country prices in Table 3. The real capital-formation ratios in the other 12 countries have been lower than the nominal capital-formation ratios in every period except for 1990-94. The decline in real ratios during the 1970s and from the late 1980s to the early 1990s was much less than the nominal ratios suggest. Since the beginning of the 1980s, the average real capital-formation ratios for these countries have stayed around 20 percent.

As Table 4 indicates, the relation of the United States to the other 12 countries looks very different when measured in terms of real shares of conventional capital formation in GDP, with constant world prices, as opposed to being viewed in terms of nominal shares, measured according to current own-country prices. These figures tell a very different ▲▼❑❐❙

from that of Table 1. United States investment ratios in real terms have been closer to those of the other countries; they were moving toward the average, and, by 1990-94, were only 3 percent below the average of the 12 other countries. The U.S. ratios were even above average in 1993 and 1994. In real terms, the United States ranked third in 1994 among the 13 countries—below only Canada and Japan—in the ratio of conventional capital formation to output.

Table 4

Real Ratios of Conventional Capital Formation to GDP: United States Relative to 12 Other Developed Countries

1970-74	82.0
1975-79	84.3
1980-84	91.9
1985-89	92.9
1990-94	97.5

NOTE: Ratios have been adjusted for purchasing power parities.
SOURCE: Kirova and Lipsey (1997), Appendix B, Table B-1.

THE MEASURE OF CAPITAL FORMATION

Gross vs. Net Capital Formation

The capital stock that enters production functions is the net capital stock, and additions to the stock are measured by net rather than gross capital formation. Despite the theoretical advantages of the use of net capital formation, much empirical research, especially that involving comparisons among many countries, has concentrated on gross capital formation, a tradition that goes back to Kuznets (1937). We follow that tradition, confining our attention to gross capital formation. There are several reasons for that choice. One is skepticism regarding available measures of capital consumption, and particularly their comparability among countries (Blades and Sturm, 1982). For example, Hayashi (1986) pointed out that Japanese depreciation had been calculated on the basis of historical cost, and that the adjustment to a replacement-cost basis amounted to as much as 30 percent of reported private saving in some years. Another reason for the use of gross measures is the belief that the introduction of new capital equipment brings new technology into the production process, whether or not the new equipment is nominally a replacement for old equipment embodying past technology. If technology, rather than the "volume" of capital equipment, is what drives economic growth, then gross capital formation, rather than net, is relevant for explaining growth. A country in which gross capital formation is equal to calculated depreciation and therefore results in no net capital formation would nevertheless reap economic growth from the substitution of new technology for old.

Since we are not studying the relation of capital formation to growth here, we cannot draw a conclusion as to which concept of capital formation is more relevant empirically. We can only mention the caution that a shift in the composition of capital formation that changes the average length of life of capital goods (e.g., from buildings to computers) would change the relation of net to gross capital formation.

Broadening the Definition of Capital Formation

The conventional measures of capital formation have remained essentially unchanged since most countries began publishing national accounts.[3] Many expenditures that fit the economic definition of capital expenditures, in that they yield income over a period beyond the current one, are excluded from our study, despite the theoretical reasons for including them. One reason for limiting the measurement is the lack of data on some types of investment, especially for international comparisons. Most of the empirical research on broadening the definition of

[3] In a recent exception, the U.S. National Income and Product Accounts adopted the standard definition of investment according to the UN System of National Accounts (which includes government capital formation) long after that definition had been applied to U.S. and other accounts by the OECD. The change also represented a return to the scope of investment in, for example, Kuznets (1937).

capital formation has been done only for the United States or, sometimes, for a few other countries. That fact limits our country coverage and, in some cases, forces us to depend on rough approximations to the measures we would like to use, even for the 13 countries we have covered.

Most of the empirical studies of economic growth that have included nonconventional elements of capital formation have concentrated on education as an aspect of human capital investment, and on research and development as an aspect of intangible, nonhuman capital investment. We have included both of these here, as best we could, and have added two others: capital formation in the form of consumer durables, of which motor vehicles are the largest part, and military capital formation, which meets the criterion of usefulness beyond the current period. Ideally, if these data are to be viewed as determinants of economic growth, the choice among investment concepts should be made empirically.

Consumer Durables. In the conventional national accounts, consumer durables expenditures are classified not by the nature of the goods or by their use, but by the institutional characteristics of the buyers—business or household. The arbitrary nature of this division is avoided for housing by the treatment of house purchases as capital formation and the inclusion of imputed income and output from home ownership. We extend the same treatment to consumer durables, a procedure strongly endorsed by Alfred Marshall more than 100 years ago.[4] These goods produce services over a long period of time, and the services are, in many cases, very similar to those yielded by the durables bought by business. Cars, the largest item in consumer durables, give transportation service whether they are owned by businesses or by households. Some cars owned by businesses are leased for household use. Refrigerators, freezers, and washers often provide services to households even if they are owned by businesses. In fact, the distinction between consumer and producer durables in the national accounts rests on ownership rather than on their function. The effort to allocate sales of some durables, especially motor vehicles, between households and businesses has been a difficult and frustrating chore for the BEA for many years.

To treat purchases of consumer durables as capital formation in the same way as purchases of owner-occupied housing, we must make two adjustments. One is to add to conventional gross fixed capital formation household expenditures on consumer durables, which are treated as consumption in both the United Nations System of National Accounts (SNA) and the United States National Income and Product Accounts (NIPA). The second is to add to consumption and output a measure of the current services yielded by consumer durables.

The comparison between the shares in GDP of nominal capital formation in consumer durables in the United States and in the other 12 countries is described in Table 5. The GDP share of investment in consumer durables has been higher in the United States than in the other 12 countries in every period. The United States has invested, on average, 6.1 percent of its total income in consumer durables, while the other 12 OECD countries have invested an average of 5.6 percent. The country with a particularly low investment in consumer durables was Japan, with an average of 3.6 percent of total income invested in durables, while Belgium was the leader (7.9 percent), followed by Canada (7.6 percent) and the United States (6.1 percent). During the 1970s, the real stock of consumer durables per capita in the United States was about four times that of Japan. The main difference between consumer durables spending in the United States and other countries was spending for motor vehicles. Over the period 1970-94, half of all durable goods expenditures in the United States were for personal transport equipment. Similar allocation patterns were observed in the United Kingdom (48 percent of all durables spending on motor vehicles), Finland (46 percent), and Denmark (45 percent). The share of motor vehicles spending was much lower in Belgium (29

[4] Alfred Marshall (1890) wrote, in discussing a narrow concept of investment, ". . . it compels us to regard as capital the yachts, but not the carriage, belonging to a yacht builder. If therefore he had been hiring a carriage by the year, and instead of continuing to do so, sold a yacht to a carriage builder who had been hiring it, and bought a carriage for his own use, the result would be diminished by a yacht and a carriage. . . . though nothing had been destroyed, and though there remained the same products of saving . . . productive of as great benefits to the individuals concerned and to the community as before. . . ."

percent), Japan (32 percent in 1975), Canada (35 percent), and Italy (35 percent).

Education. Many forms of human capital formation would, ideally, be included in a broad measure. However, for practical reasons of data availability, empirical measures have been confined to studies dealing with comparisons of educational enrollment or expenditures among countries. Some studies of economic growth have used enrollment at various schooling levels or measures of educational attainment, derived from census data or estimated from past enrollment data. Others use current education expenditures, as we do (capital expenditures for buildings and equipment are already included).

Education expenditures, whether by governments, employers, or households, are expected to yield returns over long periods of time. Some, perhaps most, of the returns take the form of higher earnings in the labor market. We do not confine the definition of investment to those entering the labor force any more than conventional capital expenditures are so confined; there is plenty of evidence that returns to education are not only long-lasting but important in the nonmarket economy as well. Many of these returns, including the effects on children's educational attainment and performance, have been studied empirically. Education also affects individual decisions about smoking and other health-related factors. However, some have argued that these health and education decisions reflect differences among individuals in their time horizons and preferences.

Our data do not include two large elements of human capital accumulation. One is on-the-job training, particularly if it is the "general" training that workers pay for by working for temporarily low wages (Becker, 1964). The other is the earnings foregone by students while they are pursuing an education. In both cases, estimates have been made for individual countries but not, by the same methods, for any substantial group of countries. It is clear from individual country estimates that the missing portions are large compared with those we include.[5] The omission of foregone earnings is probably more important in the United States than in the other countries because the support given to college and graduate students in the United States is smaller than in the other countries and because youth unemployment is lower in the United States.

Table 5

Percent Share in Nominal GDP of Nominal Capital Formation in Consumer Durables

	United States	12 Other Countries
1970-74	6.3	5.6
1975-79	6.4	6.0
1980-84	5.5	5.4
1985-89	6.5	5.9
1990-94	6.0	5.4

NOTE: GDP has been adjusted to include the estimated value of services yielded by consumer durables.

SOURCE: Kirova and Lipsey (1997), Appendix B, Table B-2.

Education is what is described in the International Comparison Program (ICP) as a "comparison-resistant service." Deflators (purchasing power parities) are provided for calculating real consumption, but it is difficult to compare either the quantity of educational output—that is, learning—or even the quantities of inputs, since the qualifications of teachers at given levels of school may differ greatly among countries. International test comparisons may provide some clue to quality of schooling, but so far these cover a very narrow slice of what schools are supposed to be teaching.

The comparison between the GDP shares of nominal expenditures on education in the United States and in the 12 other countries is described in Table 6. Over the period that we cover, the United States has spent, on average, 6.5 percent of its total income on education, while the other 12 countries have averaged 5.5 percent. As was the case for consumer durables, the gap between the United

[5] Mincer (1989) presents estimates of the annual costs of training in the United States for 1976 and 1982 which suggest that job-training costs in the United States amount to about 80 percent to 90 percent of public and private expenditures on education. Kendrick (1976) estimates that, for the United States in 1969, total gross investment on education and training was $192.3 billion, of which $92.3 billion was earnings foregone by students.

Table 6

Percent Share in Nominal GDP of Nominal Expenditures on Education

	United States	12 Other Countries
1970-74	7.1	5.1
1975-79	6.7	5.6
1980-84	6.2	5.6
1985-89	6.0	5.4
1990-94	6.6	5.6

SOURCE: Kirova and Lipsey (1997), Appendix B, Tab B13.

Table 7

Percent Share in Nominal GDP of Nominal Expenditures on R&D

	United States	12 Other Countries
1970-74	2.4	1.5
1975-79	2.2	1.5
1980-84	2.5	1.7
1985-89	2.8	2.0
1990-94	2.7	2.1

NOTE: GDP has been adjusted to include business enterprise expenditures on R&D.

SOURCE: Kirova and Lipsey (1997), Appendix B, Table B-4.

States and the other countries was largest in 1970-74 and smallest during the 1980s. Canada was the leader in educational spending, with an average of 6.8 percent of GDP invested in education, followed by the United States (6.5 percent) and Denmark (6.3 percent). Japan and Germany were the outliers in this respect, spending much less on education than other countries did (4.1 percent and 4.4 percent, respectively).

Research and Development. Research and development expenditures are probably more forward-looking than most investments in equipment. While the private depreciation rate may be high, as imitators rush to catch up with innovators, the social rate of depreciation may be low, because the usefulness of new knowledge endures. Whatever the speed of imitation, high rates of R&D seem to promote rapid economic growth.

Incorporating R&D expenditures into the measures of capital formation involves, in some cases, an addition to the measure of total output as well. The shift of government and private nonprofit R&D does not require any adjustment to GNP or GDP, since they are treated in the SNA and the U.S. NIPA as government and household-sector consumption, and therefore as final products. However, business enterprise expenditures on R&D are treated in these accounts as costs of current production. Treating these as capital formation and removing them from current expenditures on inputs raises the level of business enterprise income and gross output.

The comparison between the shares in GDP of nominal expenditures on research and development in the United States and in the other 12 countries is described in Table 7. United States investment in research and development has been consistently higher relative to total income than the average of the other 12 countries studied. Over the period 1970-94, R&D expenditures in the United States accounted for 2.5 percent of GDP, on average, compared to 1.8 percent in the other 12 countries. The trend seems to be for the R&D expenditures in other countries to move closer to those of the United States. Germany's and Japan's R&D expenditures have been relatively high among the other countries and very close to those of the United States, with an average of 2.4 percent of GDP invested in R&D. The figures for Sweden and the United Kingdom are 2.3 percent and 2.2 percent, respectively, while Canada, close to the United States in many respects, has been a relatively small investor, with an average of 1.3 percent of GDP invested in R&D.

Military Capital Formation. It is conventional, and part of both the SNA and the NIPA, to treat expenditures on construction, as well as equipment for defense, as current

government consumption, rather than capital formation. Yet, whatever their other faults and virtues, and whatever their effects or lack of contribution to the growth of nonmilitary output, these expenditures are intended to yield output over a long period of time. If we are interested in the extent to which a country sacrifices present consumption for future gains, these expenditures are as relevant as those for civilian capital formation. A more radical view would argue that almost all military expenditures are a form of investment, since they provide not only current protection but protection extending into the future. If high levels of U.S. spending on military personnel, ammunition, fuel, and other non-equipment items forced an end to the Cold War, they could be thought of as having very long-lasting impacts on U.S. (and perhaps worldwide) welfare.

The comparison between military capital-formation ratios of the United States and the other 12 countries is described in Table 8. It is no surprise that in this relatively small item, U.S. spending has been much larger relative to GDP than the average for the other 12 countries, ranging between two and three times as great. Again, Japan's spending has been at a particularly low level (0.2 percent of GDP, on average), partly because of the restrictions imposed in the peace treaty after World War II. The United Kingdom, on the other hand, has spent a relatively large part of its low aggregate investment on this item (1.2 percent of GDP, on average).

Table 8

Percent Share in Nominal GDP of Nominal Military Capital Formation

	United States	12 Other Countries
1970-74	1.5	0.5
1975-79	1.0	0.5
1980-84	1.4	0.6
1985-89	1.7	0.6
1990-94	1.3	0.5

SOURCE: Kirova and Lipsey (1997), Appendix B, Table B-5.

Comparisons of the Broader Measure of Capital Formation

The types of investment to be included in the definition of capital formation are important to international comparisons because the composition of investment differs among countries. One of the reasons for the large gap between capital-formation ratios in the United States and in the other 12 countries in conventional comparisons is that conventionally defined capital formation is a much smaller part of broadly defined capital formation in the United States.

Table 9 shows the changes in capital-formation ratios in the United States and in the other 12 OECD countries that result when we adjust the ratios to include nonconventional forms of investment and to account for price differences across countries and over time. With very few exceptions, every one of the unconventional forms of investment was more important in the United States in every period of our study. Furthermore, the unconventional forms of capital formation, as a group, were more important in the United States than in other countries in every period. Including the nonconventional types of capital formation in the comparison clearly brings the United States closer to the other countries.

Table 10 gives the comparison of investment shares, including nonconventional forms of investment and taking account of price differences across countries. By the broadly defined real capital-formation measure, the ratio of capital formation to GDP in the United States was equal to that in the other 12 countries over the period since 1970 as a whole. In the last period, the U.S. ratio was 7 percent above average, as compared with the 17 percent below average in the nominal, conventionally defined, figures of Table 1.

The indications here are that broadly defined capital formation in the United States has not at any time since the early 1970s been much below that of other

Table 9

Percent Change in the Ratio of Capital Formation to GDP Generated by Each Adjustment

	United States					
	Consumer Durables	Education Expenditures	R&D	Military Capital Formation	Constant World Prices	All Adjustments†
1970-74	+ 4.4	+ 7.1	+ 2.1	+ 1.5	– 0.2	+ 13.4
1975-79	+ 4.4	+ 6.7	+ 2.0	+ 1.0	– 0.8	+ 11.6
1980-84	+ 3.6	+ 6.2	+ 2.2	+ 1.4	– 0.9	+ 10.7
1985-89	+ 4.6	+ 6.0	+ 2.4	+ 1.7	+ 0.5	+ 14.4
1990-94	+ 4.2	+ 6.6	+ 2.4	+ 1.3	+ 3.1	+ 18.8

	12 Other Countries					
	Consumer Durables	Education Expenditures	R&D	Military Capital Formation	Constant World Prices	All Adjustments†
1970-74	+ 4.0	+ 5.1	+ 1.3	+ 0.5	– 2.3	+ 7.6
1975-79	+ 4.5	+ 5.6	+ 1.3	+ 0.5	– 1.8	+ 9.1
1980-84	+ 4.1	+ 5.5	+ 1.5	+ 0.6	– 1.2	+ 9.3
1985-89	+ 4.4	+ 5.4	+ 1.7	+ 0.6	– 0.7	+ 10.9
1990-94	+ 3.8	+ 5.5	+ 1.8	+ 0.5	+ 0.4	+ 13.0

SOURCE: Kirova and Lipsey (1997), Appendix A, Tables.

† The changes generated by the individual adjustments do not add up to the change generated by all adjustments because some of the adjustments to the measure of capital formation require a corresponding adjustment to the measure of GDP, while others do not. The "All Adjustments" column gives the change in the ratio of capital formation to GDP when the measure of capital formation is adjusted to incorporate price changes and all nonconventional forms of investment, and the measure of GDP is adjusted to incorporate price changes, the estimated value of the services of consumer durables, and business enterprise R&D expenditures.

Table 10

Percent Share of Real Capital Formation in Real GDP: United States Relative to 12 Other Countries

	Including Only Consumer Durables	Including Only Education Expenditures	Including Only R&D Expenditures	Including Only Military Capital Formation	Including All Nonconventional Forms
1970-74	86.8	92.6	86.4	86.8	98.9
1975-79	86.8	91.3	87.8	86.8	94.2
1980-84	91.4	95.8	95.4	95.8	100.0
1985-89	95.7	96.8	96.6	98.7	102.4
1990-94	101.6	102.2	100.5	102.6	107.4

SOURCE: Kirova and Lipsey (1997), Appendix A, Tables.

developed countries relative to total output. Over the last 10 years, U.S. capital-formation ratios have been above the average for the group. Even for believers in the role of capital-formation rates as determinants of future growth, there is nothing in these data that suggests any tendency for the other countries to soon catch up to the United States in per capita output.

Comparisons of Capital Formation, per Capita and per Worker

In most calculations of resource abundance, the United States is found to be a relatively capital-abundant country, with a high ratio of capital per worker and per individual in the population. The comparisons for both capital formation per worker and capital formation per capita, even in terms of conventionally defined capital, as given in Table 11, suggest that this high capital abundance will continue. The United States has been investing more per person in the population and more per worker than the other countries for the whole quarter century in our data. In the early years, the margin was higher in investment per worker because the ratio of employment to population was lower in the United States, but with rising unemployment in Europe and rising labor force participation in the United States, the differential in the per capita ratio was higher at the end of the period.

The ratios for broadly defined capital formation (Table 12) show a considerably larger margin in favor of the United States. The use of the broader definition of capital formation enlarges the gap in favor of the United States, especially in the early 1970s, when the other countries' nonconventional capital formation was particularly low. Since then, for two decades, the United States has been adding, in gross capital formation, about 30 percent more than the average developed country to the capital provided for each worker and for each resident of the country. It would appear that U.S. industry will continue to be relatively capital intensive in the future.

Table 11

Real Capital Formation Conventionally De ned, per Capita and per Worker: United States as Percent of Average of 12 Other Countries

	Per Capita	Per Worker
1970-74	118.7	125.4
1975-79	117.6	118.1
1980-84	121.3	119.7
1985-89	121.0	116.6
1990-94	124.3	117.7

SOURCE: Kirova and Lipsey (1997), Appendix B, Table B-1.

Table 12

Real Capital Formation Broadly De ned, per Capita and per Worker: United States as Percent of Average of 12 Other Countries

	Per Capita	Per Worker
1970-74	149.7	157.6
1975-79	137.3	137.5
1980-84	135.4	132.9
1985-89	139.6	133.8
1990-94	144.6	136.6

SOURCE: Kirova and Lipsey (1997), Appendix B, Table B-6.

CONCLUSIONS

Conventional measures of nominal capital formation give a misleading picture of the level of capital formation in the United States and other developed countries, changes over time, and the way U.S. capital formation compares with shares of capital formation in GDP in other developed countries. Measures of capital formation in real terms, taking account of price changes and price differences across countries for capital goods and other goods and services, paint a very different picture of the last quarter-century. When a broader concept of capital forma-

tion is used, the picture changes even more; we argue that this new perspective, which is at least as appropriate as the conventional one in national accounts, is more consonant with the economic definition of capital formation.

Conventional measures show the U.S. ratio of capital formation to GDP ranging from 10 percent to 25 percent below the average of the other countries, with the United States falling further behind the other countries since the beginning of the 1980s. In contrast, when we take account of the changes in prices of capital goods relative to other prices over time and differences in the prices of capital goods across countries, U.S. investment ratios in real terms are shown to have been increasing over time and moving toward the average of other developed countries, with the differential falling to less than 5 percent in 1990-94.

When the concept of capital formation is broadened, as we argue it should be, to include household purchases of consumer durables, current expenditures on education, R&D, and military capital formation, and when account is also taken of international price differences, the United States is shown to have never been, since 1970, far below the other countries in the share of GDP devoted to capital formation. By 1990-94, the share of real broadly defined capital formation in real GDP in the United States was more than 5 percent higher than the average in other developed countries.

Real U.S. capital formation—per capita and per worker—even conventionally defined, was between 15 percent and 25 percent higher than in the other developed countries over the period 1970-94. This margin in favor of the United States is considerably higher when we compare the adjusted broadly defined capital formation per capita and per worker. In terms of broadly defined capital, the United States has been investing between 30 percent and 60 percent more per worker and per resident than other developed countries. This suggests that the United States will continue to be a relatively capital-abundant country in the future.

As we have pointed out, these are not the only definitions of capital formation that have some theoretical basis. The adjustments to the conventional measures suggested here were selected on the basis of reasonable feasibility without major research. The others that we consider of equal theoretical merit—on-the-job training costs and foregone earnings of students—were omitted solely for lack of data, but claims have been made also for including some part of health care expenditures and child-rearing costs in capital formation.

A next step would be to compare the usefulness of several versions of capital formation, varying in scope, for various purposes such as the explanation of economic growth. We hope to turn to this question next.

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Appendix

ADJUSTMENTS AND DATA[1]

Consumer Durables Adjustment

Treating purchases of consumer goods as capital expenditures rather than as consumption requires estimates of the amount of these expenditures and of the value of the services of consumer durables, presumably equivalent to what would be charged for them if they were provided by the business sector. The consumer goods expenditures are added to the conventional capital formation, and the value of services they provide is added to the conventional GDP.

Data on total durable goods expenditures for the period 1970-94 are available from the OECD *National Accounts*, Vol. II, Table 2, for 10 of the countries we cover: Canada, Denmark, Finland, France, Japan, Netherlands, Norway, Sweden, the United Kingdom, and the United States. For Belgium and Italy, durable goods expenditures were approximated by the sum of expenditures on furniture, furnishings, household equipment, and personal transportation equipment, from the same source.

For Italy, although measures of total durables expenditures were reported, we approximated durables expenditures with the spending on furniture, furnishings, household equipment, and personal transportation, because the reported total durables expenditures seemed unreasonably high. Both the implied share of durables expenditures in final household consumption expenditures and the level relative to the two subgroups were far out of line with those of other countries.

We used actual expenditures on personal transportation equipment and our estimates of expenditures on furniture, furnishings, and household equipment to calculate the amount of durable goods expenditures for Germany. Data for total expenditures on the broader group—furniture, furnishings, household equipment and operation—and an average share of the expenditures on the durable items—furniture, furnishings, and household equipment—were used to estimate expenditures on durables. ICP data for 1970, 1975, 1985, 1990, and 1993 were used to calculate the average share.

The value of services provided by durable goods is estimated on the basis of stocks of capital goods, as in an earlier BEA study. Data on the net current stock of consumer durables are available only for Canada and for the United States from the national balance sheets. Data are available on Japan's stock of the major consumer durables from the National Accounts of Japan. Following Horioka (1995), we used the average ratio of expenditures on all consumer durables to those on the major consumer durables to estimate the stock of all consumer durables in Japan. For all other countries, we made a rough estimate of the stock of consumer durables in 1970, assuming that it equals four times the expenditures on durables during the year, an approximation that has been used before by Goldsmith (1985). Then we used the perpetual inventory method, assuming a 20 percent rate of depreciation, to estimate the net stock of consumer durables for the period 1971-94. The value of services provided by consumer durables was estimated to equal 34 percent of the previous year's net stock of consumer durables (20 percent depreciation cost, 11 percent net return, 3 percent operating costs), following a methodology suggested by Katz (1982) in the BEA study.

Educational Expenditures Adjustment

The main source of data on education expenditures is the OECD *National Accounts*. In countries that provide complete data on both government and household consumption expenditures, the total of government and household expenditures on education was used. For countries in which government expenditures are not reported by the OECD, data on current expenditures for public education, collected by UNESCO and published in the UN *Statistical Yearbook* were used instead. In some cases, depending on the

[1] Appendices A and B, containing the data and summary tables of results, are available in Kirova and Lipsey (1997) and on the Internet at http://www.stls.frb.org/research/reviewdat.html.

availability of data, public or public and private expenditures reported in the OECD *Education Statistics 1985-92* were used.

For Germany, which does not report household expenditures on education, data on education fees paid by households from the ICP for 1980, 1985, 1990, and 1993 were used to obtain ratios of private to public expenditures. We then used the average of these ratios to interpolate and extrapolate household education expenditures in Germany.

The OECD figures for household expenditures seem to match the figures given by "fees" in the ICP reports. It thus appears that the OECD data understate nongovernment education expenses by omitting that part paid for from sources other than fees.

R&D Expenditures Adjustment

The adjustment for R&D requires not only the addition of total R&D expenditures to capital formation, but the addition of business R&D expenditures to GDP, since the standard accounts treat them as an expense of production rather than as a product. R&D performed by government and the nonprofit sector are already in GDP, but as consumption rather than as capital formation.

Most of the R&D data were taken from various issues of OECD *Science and Technology Indicators, Basic Statistical Series* and from the OECD *Basic Science and Technology Statistics 1981-1994*. Data for missing years were interpolated on a straight line.

Military Spending Adjustment

Data on total military expenditures were obtained from the U.S. Arms Control and Disarmament Agency, *Report on World Military Expenditures and Arms Transfers*. For NATO member countries, we used the share of equipment and infrastructure expenditures, reported in the *NATO Review*, to calculate military capital expenditures. For the other OECD countries, we used the average NATO member countries' share of equipment and infrastructure expenditures in total military expenditures to obtain an estimate of their military capital expenditures.

Cross-Country Comparison in International Prices

To account for the difference in the prices of investment goods relative to the prices of other goods and services across countries, we converted the nominal measures of capital formation and GDP at national prices in national currency to real measures at international prices. The calculations are all in each year's current prices, with the United States purchasing power parities (PPPs) always set at 1.00.

To make the conversion, we use data on PPPs for gross fixed capital formation and for GDP from the Penn World Table (Mark 5.6), which provides data through 1992. We extrapolated 1993 and 1994 PPPs for gross fixed capital formation and for GDP by data on price indices of GDP and of gross fixed capital formation reported in the OECD *National Accounts*, Vol. I.

The Penn World Table does not provide purchasing power parity estimates for a detailed breakdown of GDP. To calculate the nonconventional elements in our broad measure of capital formation, we use price and quantity data from the OECD. These data are a component of the ICP, but there are some differences in the method. Some data have been published by Eurostat (1988) and OECD (1985a, 1987, and 1992), but we made use of more detailed data on diskettes provided by the OECD covering the years 1985, 1990, and 1993. The weighting systems and the index number formulas used by the Penn World Table and the OECD are different, but it was not possible for us to obtain exactly comparable measures.

For consumer durables, PPPs were available from the OECD data mentioned above and, for earlier years, from Kravis, Kenessey, Heston, and Summers (1975) and Kravis, Heston, and Summers (1978 and 1982). Since it was clear from these earlier studies that PPPs for consumer

durables were more strongly correlated with those for gross fixed capital formation than with those for consumption, we used the annual PPPs for gross fixed capital formation to convert the nominal measures of capital formation in consumer durables to real measures. For converting the nominal measures of educational expenditures and expenditures on R&D, we used the PPPs for GDP as deflators. We used PPPs for gross fixed capital formation to deflate military capital formation expenditures.