

THE U.S. PRODUCTIVITY SLOWDOWN: WHAT THE EXPERTS SAY

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U.S. productivity growth has slowed significantly since 1973; moreover, U.S. productivity continues to grow at a slower rate than that of our major trading partners. What caused these things to happen? The answer to this question is still unsettled, although a number of potential explanations are being debated in the economics literature. These include energy prices, labor quality, measurement error, adequacy of mineral resources, governmental regulations, investment opportunities, managerial practices, and governmental trade policies. These explanations will be discussed in this article.

Two measures of productivity are commonly used. Labor productivity, or output per hour, is the simpler of the two to construct. To measure output per hour in the nonfarm business sector, one must first measure nominal output, defined as the market value of final goods and services produced in that sector. Then one must deflate the nominal output by the relevant price index to obtain real output. The final step requires dividing the estimate of real output by the number of hours worked in the nonfarm business sector to get per hour output.

Quarterly labor productivity data for the U.S. nonfarm private business sector from 1947 to 1987 are plotted on Chart 1. The chart shows actual labor pro-

ductivity plotted relative to the 2.4 percent per year trend that it averaged in 1947-73 and the 1 percent per year trend that it averaged in 1973-88.

Total factor productivity (TFP) is another way of measuring productivity. The TFP measure is popular among growth analysts because it provides information on the sources of economic growth. More precisely, TFP specifies the relative contributions to growth attributable to labor inputs, capital inputs, land inputs (occasionally), and productivity—the latter being the name given to the residual component of growth not attributable to the other three inputs. The productivity residual thus measures how efficiently the inputs of labor, capital and land are used in producing output. The actual estimation of TFP is complicated. Readers interested in studying total factor productivity in more detail might begin by reading the BLS publication, "Trends in Multifactor Productivity, 1948-81" [23], which contains references to other important works.

Chart 2 illustrates the different time paths of labor productivity (output per hour) and multifactor productivity (the BLS name for its measure of total factor productivity) over the 1948-88 time period. The chart illustrates that multifactor productivity growth after 1973 slowed by about the same amount as labor

Chart 1
Logs (Base 10) 1947:1 To 1988:4, Trend Break 1973:2

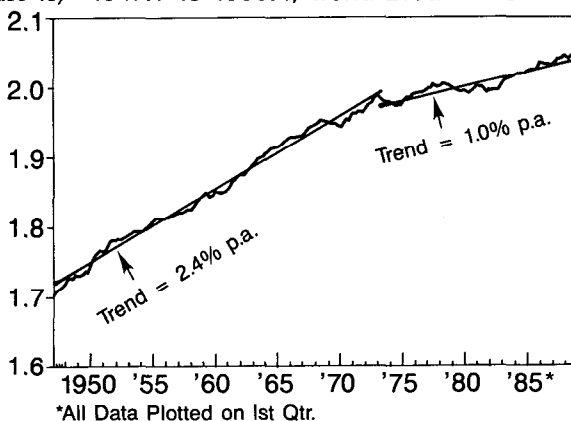
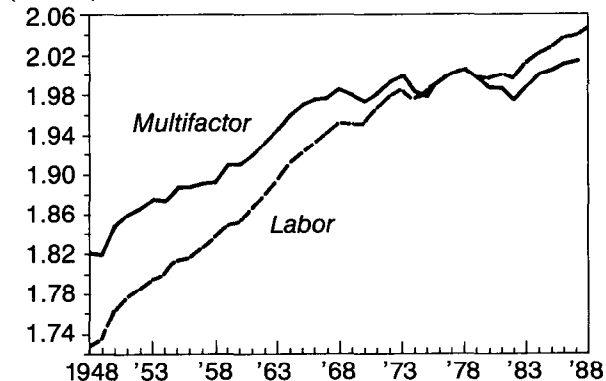


Chart 2
Logs (Base 10) Multifactor and Labor Productivity Nonfarm Business Sector



productivity growth. In 1948-73 multifactor productivity averaged 1.7 percent growth per year, but the rate slowed to 0.2 percent in 1973-88.

Table I shows the growth in average U.S. labor productivity in the pre- and post-1973 periods in comparison to the productivity growth of selected other countries. The table shows that productivity growth worldwide has declined since 1973, but it also illustrates the second part of the productivity puzzle, that U.S. productivity growth, at 0.6 percent per year, remains well below that of a number of other countries.

I. THE DECLINE IN U.S. PRODUCTIVITY GROWTH SINCE 1973

In 1985, Edward Denison [10] published an exhaustive study of the U.S. productivity slowdown. He concluded that four factors clearly contributed to the post-1973 slowdown, two modestly and two substantially. The modest contributors were: 1) a decline in investment per worker and 2) more intensive environmental and worker protection regulations. The major contributors to the slowdown were: 1) the end of the population shift from low productivity farm and self-employed jobs to higher productivity jobs (15 percent of the slowdown), and 2) the effects of the 1973-75 and 1980-82 recessions on economic growth (16 percent of the slowdown).

In all, the Denison study attributed 40 percent of the post-1973 productivity slowdown to identifiable

sources. The study largely ignored the energy crisis, however, and dismissed declining labor quality as a source of slower productivity growth. This article will accept Denison's estimates of the effects of population shifts and the recessions on productivity, which together account for almost one-third of the 1.5 percentage point growth slowdown. Thus, only one percentage point per year remains to be explained.

Other possible sources of declining productivity growth include:

- Measurement error
- Declining labor quality
- Rising energy prices
- Environmental protection regulations
- Depletion of mineral resources
- Depletion of investment opportunities

Measurement Error¹

In a 1988 article [4], Martin Baily and Robert Gordon investigated whether a portion of the productivity slowdown could be attributed to measurement error. They found that there were serious

¹ This section relies heavily on the article by Martin Baily and Robert J. Gordon [4]. As the reader will observe, the section is somewhat longer than the relative importance of measurement error would seem to justify. The length of the section is justified, however, because the examples of measurement error found by Baily and Gordon are interesting in and of themselves, especially so to the financial services industries. Additionally, the examples should provide the casual reader with a necessary, but healthy, skepticism of economic data aggregates.

Table I

PRODUCTIVITY GROWTH IN THE BUSINESS AND MANUFACTURING SECTORS^a

(Average percentage changes at annual rates, selected countries)

	1960s ^b to 1973		1973-79		1979-86	
	Business	Mfg.	Business	Mfg.	Business	Mfg.
Belgium	5.0	7.2	3.0	5.0	2.4	4.1
Canada	2.9	4.1	2.0	1.2	1.3	1.4
France	5.9	6.4	3.5	4.0	2.4	2.5
Germany	4.9	4.8	3.4	3.3	2.0	2.4
Japan	8.6	10.3	3.2	5.2	2.8	6.3
Sweden	3.1	5.0	1.9	1.1	1.4	3.0
United Kingdom	3.3	4.1	1.2	0.6	1.9	3.4
United States	2.2	3.4	0.3	1.0	0.6	3.4

^a Output is value added in the business (GDP at factor cost excluding general government) and manufacturing sectors at constant prices. Productivity is labor productivity (output per employed person).

^b The starting years are as follows: Belgium 1962, Canada 1962, France 1964, Germany 1961, Japan 1967, Sweden 1964, United Kingdom 1960, and United States 1960.

Source: *OECD Economic Studies*, Spring 1988, p. 20.

problems with the way output and productivity were measured, but that, paradoxically, the problems did not help to explain much of the slowdown, basically for two reasons. First, some of the industries subject to measurement error sell much of their output to other businesses, so that measurement errors in those industries have less effect on aggregate productivity statistics. Second, there were measurement problems in earlier periods also—growth is understated now, but it was also understated before.

Baily and Gordon concluded that measurement error would account for 0.2 percentage points of the unexplained one percentage point per year slowdown in productivity growth since 1973.² They argued persuasively that although the official statistics had been underestimating productivity for years prior to 1973, measurement error had been getting worse since 1973, especially in the service sector.

Baily and Gordon observed that there was a fundamental paradox in the U.S. productivity data, namely, that the slow productivity growth has been accompanied by rapid, perhaps even accelerating, technological change. They cited a number of technological advances in the services sector, many of them emanating from the increased use of computers, which have revolutionized the processing of forms, payments, billings, and inventory control.

The finance industry, for example, offers all-in-one cash management accounts, automatic telephone machines for credit card approval, fast bill-paying by phone or personal computer, and 24-hour money machines. The airline industry offers preassigned seats and boarding passes, no-stop check-ins, frequent flyer plans, and flyer discounts aimed to the nonbusiness flyer. As a result of better inventory control, retailers can stock a larger variety of items with the same floor space. Drugstore chains have computerized prescription records. Hotel chains have frequent-stayer services, preprinted registration forms, and no-stop checkout. Restaurants, supermarkets, and hospitals provide itemized bills.

Despite these technological advances, measured productivity growth in the finance, insurance, and real estate sector is estimated to have declined at an average rate of 0.41 percent per year in the 1973-87 period after having risen an average of 1.41 percent

per year in the 1948-73 period. Productivity growth in retail trade averaged only one percent per year in 1972-86. Measured productivity in the air transportation industry also fell by 0.2 percent per year in 1972-86. This last statistic might not seem so strange, given some of the problems airlines have been facing. What makes it strange, however, is that a physical measure of productivity—scheduled airline passenger miles per employee—was rising substantially at a rate of 3.6 percent per year at the same time that conventionally-measured productivity was falling.

Baily and Gordon concluded that there is a basic problem in measuring the productivity of services. They also found problems in the measurement of productivity in air transportation and construction and found the productivity measurements in trucking and railroad transportation to be suspicious.

As noted above, labor productivity measures are calculated by first finding nominal output, then deflating that quantity by some price index. The resulting measure of real output is then divided by the number of labor units. Problems with measuring productivity almost invariably stem from problems in determining the right price index to use to get real output. This problem is particularly difficult when rapid technological changes have occurred.

For example, the personal computer used to write this article is 8-10 times faster and has twice the memory and four times the hard disk space of the 1983 model that it replaced. The total package for the old computer cost almost \$6000 in 1983, while the new computer package cost almost \$5000 in 1988. If a computer price index merely compared the prices of the two machines, it would show that computer prices in 1988 were 82 percent of what they were in 1983. In actuality, however, the new personal computer is a quite different product. As a result, such a price index would understate the actual decline in computer prices since 1983. A more appropriate measure would compare the price of the old computer to current prices of computers similar to the old one, which sell for approximately \$1500. An index based upon equivalent quality computers, therefore, would conclude that prices in 1988 were only 25 percent of what they were in 1983. The lesson is clear: an appropriate price index must take quality improvements into account.

In order to account for quality changes in the computer industry, the official price deflators for computers are derived in terms of price per computer “calculation” rather than price per computer “box.” Using this measure, the Bureau of Economic Analysis (BEA) estimated that computer prices fell during 1969-87 at a 14 percent annual rate.

² Baily and Gordon actually attributed 0.5 percentage points per year to measurement error (0.3 percentage points per year to declining labor quality) because they used a definition of total factor productivity that put changes in labor quality into the labor input. In their framework, overlooking a decline in the quality of labor would show up as a measurement error. For this article, however, declining labor quality is discussed as a distinct source of productivity decline.

Whether computer prices are measured appropriately by this index is open to debate. Edward Denison [9] argues that the current treatment of computers results in an *overstatement* of productivity growth in manufacturing, particularly in nonelectric machinery (which includes computers) since 1979. He observes that productivity measures that use GNP as the measure of output result in a double counting of the effects of computers—once as investment in nonelectric machinery and second as intermediate input embodied in final product. He also thinks the quality-adjusted computer prices used by the BEA tend to overstate the industry's real output.³

The problems in estimating the output of computers in times of rapid technological advance illustrate the difficulties involved in making productivity estimates for the manufacturing sector, where productivity is measured more accurately than elsewhere. The difficulties are multiplied when services need to be adjusted for quality changes. Baily and Gordon found a wide variety of specific measurement problems in service industries such as banking and insurance.

Consider the banking industry. It had no measured productivity growth in the 1948-73 period and only 0.05 percent growth per year in 1973-87. There are reasons to believe, however, that actual productivity in banking has increased fairly substantially since 1973. Improvements in handling paper checks and the increasing usage of electronic payments, for example, have resulted in substantial increases in real physical productivity in making payments. Loan processing has also become more efficient through the use of credit cards and lines of credit. The sustained growth in check and loan-processing productivity did not boost measured productivity in banking, however, because individual activities are weighted by their labor input shares. Thus, the more efficient activities such as credit card loans are considered to contribute less to bank output than conventional loans precisely because they utilize less labor.

Banks also have been providing customer conveniences through branching and 24-hour money machines. As a result, bank services in 1989 are a

³ Denison shows that output per hour in the total business sector—which averaged growth rates of 2.9 percent in 1948-73, 0.6 percent in 1973-79, 0.2 percent in 1979-82, and 2.2 percent in 1982-86—would have risen more slowly in 1979-82 (0.1 percent) and 1982-86 (1.8 percent) if it had not been for the exceptional productivity improvement in computer production. The slower productivity growth, of course, lies entirely within the manufacturing sector in which growth rates of 1.5 percent and 5.0 percent in 1979-82 and 1982-86 are reduced to 1.0 percent and 3.5 percent, respectively.

different (and considerably improved) product from bank services in 1970. Conventional productivity measures, however, do not consider convenience as a quality improvement, and branching is thought to reduce efficiency—it reduces the average population served by a bank office.

As another example, consider the insurance industry. The price indexes used to deflate the estimated value added in particular sectors of this industry are typically only loosely related to the true insurance "output." For example, the auto repair cost index is used to deflate value added by auto insurance, and the medical cost index is used to deflate the value added by health insurance. But these procedures lead to distortions. For example, because medical costs are rising so rapidly, the practice of deflating total value added in the health insurance sector almost certainly leads to an understating of the true growth of "output" in this industry and therefore the growth of productivity in the industry. Baily and Gordon argue "... given that the insurance industry has been able to benefit not only from computerization, but also from group policies, it is implausible that insurance costs should have risen faster than the price level for GNP" [4, p. 396].

As a result of the measurement error in banking and insurance and some questionable practices in measuring the deflator for commercial rental income in determining output in real estate, Baily and Gordon concluded that the growth of productivity in the finance, insurance, and real estate sector was probably understated by about 1.1 percent per year before 1973 and 2.3 percent per year after 1973.

Productivity growth in retail trade averaged 1.39 percent per year in 1958-72 and 1.0 percent per year in 1972-86. Baily and Gordon conclude that productivity in this sector is mismeasured because the BEA trade deflators do not consider consumer convenience to be a quality improvement, yet convenience has been one of the more important trends in retailing in the past two decades. Examples of the trend toward consumer convenience include the proliferation of sales catalogs, fast food establishments, automatic teller machines, 24-hour convenience stores, liberal store opening and closing times, laser scanners in supermarkets, and supermarkets that stock more varieties of items.

There are rather large differences between productivity in the transportation industries as measured by the Bureau of Economic Analysis and productivity measured in physical terms. The BEA estimates, for example, that productivity in the transportation industry grew at an average rate of 3.5 percent per year in 1948-73 but only 0.21 percent per year in

1973-86. In contrast, productivity measured in miles per employee rose at a fairly steady 3.3 percent per year rate over the entire 1948-86 time period, showing no significant decline after 1972. BEA-measured productivity in railroads rose only 2.2 percent per year in 1973-86, but railroad freight ton-miles per employee rose 5.5 percent per year. BEA-measured trucking productivity fell 0.3 percent per year over the 1973-86 period, while intercity trucking ton-miles per employee rose 2.3 percent per year over the same period. Airline productivity, as measured by the BEA, fell 0.4 percent per year over the 1973-86 period, but scheduled airline passenger miles per employee rose at a 3.8 percent rate.

Although Baily and Gordon did not determine the cause of the discrepancies in railroads and trucking, they found that airline productivity was mismeasured because the official statistics did not take account of airline discounts. The official BEA price deflator showed fares almost tripling between 1972 and 1986, but actual revenue collected per passenger mile increased only about 60 percent. A correction of that statistic will result in a marked increase in measured airline productivity.

Baily and Gordon concluded that productivity has probably been understated in the construction industry. The official data indicate that construction value added per hour fell 4.7 percent per year between 1967 and 1972, and fell again at a 2.2 percent per year rate between 1977 and 1986. Thus, between 1967 and 1986 measured real value added in construction fell by 12 percent despite a 40 percent rise in hours worked.

Baily and Gordon argued that real value added in construction has probably been mismeasured because the price indexes used to deflate nominal value added by construction allowed for virtually no increase in quality of output per square foot, either for residential or for nonresidential construction. In fact, the price deflators for construction have assumed no increase in quality per square foot since 1929.

As Baily and Gordon noted, price indexes based upon square footages can be biased if new features are included in houses of a particular size. Features new to residential construction since 1929 include central air conditioning, double-glazed windows, wall insulation, customized features, built-in dishwashers, and more attention to landscaping. Features new to nonresidential construction include faster elevators, more sophisticated heating and air conditioning systems, and intermediate layers between floors to allow more flexibility and access for electric lines and cooling ducts.

Labor Quality

Baily and Gordon attributed 0.3 percentage points per year of the slowdown in U.S. productivity growth since 1973 to mismeasurement of labor quality. The study of productivity and U.S. economic growth by Jorgenson, Gollop, and Fraumeni [17] concluded, as shown in Table II, that deteriorating labor quality had accounted for an even greater decline of 0.63 percentage points per year in the growth of U.S. productivity in 1973-79. Edward Denison, on the other hand, concluded that changes in the quality of the labor force contributed only a tiny amount to the productivity slowdown [10].

The Jorgenson, Gollop, and Fraumeni study decomposed labor quality by source (age, sex, education, employment class, and occupation; and various interaction measures) by industry. This decomposition enabled them to estimate the effects of these factors on labor quality (using compensation received as a proxy for quality). They found that

the age and sex factors are . . . the dominant causes of slowing growth of the quality index, [but] . . . the interaction effects of age and sex with each other and other factors are generally positive and consequently reduce the negative effect of . . . [-0.62] percent that would be inferred from summing the main effects of sex and age, . . . [-0.35] percent and . . . [-0.27] percent, respectively Yet even when all interaction effects are taken into account, the conclusion remains that the changing sex-age composition of the employed labor force has had a negative impact on labor input per hour worked. The increasing entry of women and young workers into low-paying jobs increases hours worked proportionately more than it increases labor input [17, p. 291].

Table II
ESTIMATES OF LABOR QUALITY
(Average annual rates of growth)

Source of Quality	1948-73	1973-79	Difference
	Percent	Percent	Col. 2 - Col. 1
Overall quality	0.61	-0.02	-0.63
Sex	-0.19	-0.54	-0.35
Age	-0.07	-0.34	-0.27
Education	0.66	0.36	-0.30
Employment class	0.17	-0.22	-0.39
Occupation	0.37	0.00	-0.37
Industry	0.28	0.08	-0.20

Source: Derived from Jorgenson, Gollop, and Fraumeni [17, p. 273].

Their study also showed that a considerable portion of the decline in labor quality after 1973 resulted from a diminished return to education.

There has been an ongoing discussion in the economics literature of the likelihood that the decline in the return to education stems from a decline in the quality of schooling—for example, as evidenced by the decline in the SAT scores that began in the 1960s. Baily's 1981 study [1] of the SAT score decline concluded that it could not have contributed to the post-1973 U.S. productivity slowdown because the decline was not large enough and the new entrants to the labor force did not make up a large enough fraction of the work force. A 1987 study by John Bishop [6] using not only the SAT scores but a variety of measures of general intellectual achievement (GIA) concluded that although the decline in the scores after 1967 could not explain the post-1973 slowdown, it probably did contribute to weak growth in the 1980s. That study estimated that the reduction in GIA reduced productivity growth by about 0.09 percent per year in 1973-80 and 0.24 percent per year during 1980-87 [6, p. 16].

Richard J. Murnane [18] agreed with Baily that a decline in educational quality was not responsible for the productivity decline. He stated that

both private and public reports have sounded the alarm that the nation is at risk because of the inadequacies of American education. These studies, in turn, have prompted observers to conclude that deterioration in America's schools has been a significant cause of the drop in the productivity growth rate over the past fifteen years. That conclusion is almost certainly not true. The productivity decline, especially the dramatic drop beginning in 1973, was too precipitous to blame on relatively slow-moving changes such as a possible reduction in the quality of the work force. There were some declines in scores on tests administered to elementary and secondary school students during the late 1960s and 1970s that are not well understood, but a large part of the decline in the SAT scores, the measures of educational performance given the most attention in the media is due to an increase in the number of students with relatively low ability who are taking the test. Perhaps most important, the rate of labor productivity growth has also fallen in other countries, including France, Germany, Britain, and Japan, since 1973 [18, pp. 215-16].

Murnane also noted the importance of workplace organization to productivity. He observed that the productivity of American workers in the recent General Motors-Toyota NUMMI automobile project rivaled the productivity of workers in Toyota plants in Japan after two years, mainly because of the use of the Japanese management system. This management system included such things as worker teams responsible for quality control, a just-in-time inventory system, and team standardization of tasks. This

increase in productivity was particularly significant as GM had previously closed down the plant and eighty percent of the labor force used in the joint venture consisted of workers previously laid off. This example also calls into question the assertion that the U.S. worker is of a relatively low quality.

Murnane is, however, concerned about the effects of education on future productivity. He observed that the skills that seem particularly important to worker productivity are

... the ability to understand directions (even when the manuals are poorly written), to ask questions, to assimilate and synthesize unfamiliar information, and to identify and solve problems that occur during the normal working day; in short, literacy and problem-solving skills in specific contexts [18, p. 223].

He cited studies that show Americans may not be acquiring these basic skills, in particular, the 1986 study for the National Assessment of Educational Progress (NAEP), which found that while 90 percent of 21-25 year old American adults could follow simple directions and solve single step problems, more than 30 percent had difficulty with nonroutine or multistep problems. The item scores indicated, moreover, that the problem was not basic reading skills but an inability to use reading to solve multistep problems. The 1986 NAEP mathematics assessment concluded about American students' math skills, a proxy for their problem-solving skills, that

the fact that nearly half of the 17-year-olds do not have mathematical skills beyond basic computation with whole numbers has serious implications. With such limited mathematical abilities, these students nearing graduation are unlikely to be able to match mathematical tools to the demands of various problem situations that permeate life and work [18, p. 225].

Murnane had several suggestions for improving the U.S. educational system. One of the more interesting was that since the types of achievement tests most often used by districts and states create incentives for teachers to focus instruction on arithmetic computation skills and word recognition skills rather than on the more difficult to assess problem-solving and literacy skills, the achievement tests should either be modified or given less weight in teacher evaluation.

Higher Energy Prices after 1973

The effect of the higher energy prices on productivity growth is one of the more hotly debated topics in the economics literature. A number of economists think that increases in such prices after 1973 had a major effect on worldwide productivity growth, while others think energy played a relatively minor role.

Dale Jorgenson [15] concluded that higher energy prices after 1973 were important determinants of the productivity slowdown. Jorgenson's study disaggregated the economy into sectors and then further broke down sectoral output growth into separate source components, namely, labor inputs, capital inputs, intermediate materials inputs, and productivity. These steps enabled him to study the characteristics of productivity growth by industry.

In an earlier study [16], Jorgenson and Fraumeni had classified productivity-growth in 35 major U.S. industries as capital saving or using, labor saving or using, energy saving or using, or materials saving or using. These classifications are useful for determining the effects of relative price increases of the various factor inputs on productivity growth. If, for example, an industry's productivity growth was capital using, an increase in the price of capital would lead to a slowdown in productivity growth, but if the industry's productivity growth was capital saving, increased capital prices would increase productivity growth in that industry.

Jorgenson and Fraumeni found the most common type of productivity growth, in 19 of the 35 industries, to have been capital using, labor using, energy using, and materials saving. They also found that productivity growth was *energy using* in 29 of the 35 industries studied. This last finding implied that increases in energy prices cause reductions in aggregate productivity growth.

Jorgenson [15] argued that the most striking change in the relative prices of capital, labor, energy, and materials inputs after 1973 was the substantial increase in the price of energy. He pointed out that real energy prices rose 23 percent in 1973-75 and 34 percent in the two years following the Iranian revolution in 1978. He concluded that

this evidence provides part of the solution to the problem of disappointing U.S. economic growth since 1973. Higher energy prices are associated with a decline in sectoral productivity growth for 29 of the 35 industries [studied]. . . . The resulting slowdown in sectoral productivity growth is more than sufficient to explain the decline in U.S. economic growth [15, p. 34].

Zvi Griliches [14] also agreed that energy is the prime suspect as a cause of the post-1973 productivity slowdown. He stated that

it is not just that many industries had to face new prices, change the way they used their factors of production, and scrap much of their now unprofitable capacity, but there was also a long worldwide recession induced by the fall in real wealth caused by OPEC, by the fall in aggregate demand caused by governments trying to control the resulting inflation, and the subsequent fall in U.S. exports and the increase in import competition in the early 1980s as

the result of rising dollar exchange rates. These factors combined together to produce one of the longest worldwide recessions and growth slowdowns from which the world may not yet have emerged [14, p. 19].

Some economists argue that energy played a smaller role in the productivity slowdown. Those economists point to discrepancies between the timing of the oil price increases and the productivity slowdowns in oil-related industries. As Baily and Gordon put it,

at first glance, industry productivity data suggest that the increase in energy prices in 1973 had an effect on productivity. Mining and utilities, two of the industries most heavily affected by the energy crisis, had the biggest post-1973 slowdowns. Transportation, too, had a major slowdown. On closer inspection, however, the impact of energy is not so clear. Both mining and utilities had begun to slow down before 1973. The depletion of easily available oil reserves in oil extraction, health and safety regulations in coal mining, and the depletion of innovation and returns to scale opportunities in electric power, together with the effect of environmental regulations, were reducing growth before the energy crisis hit. In the transportation sector, too, the timing seems a little off. This sector slowed less after 1973 than it did after 1979, a period when energy prices began to come down [4, pp. 362-63].

Mancur Olson [20] disputes this point. Although he agrees that the productivity growth began to slow slightly before the first oil shock (1973), he argues that all studies show the dramatic drop in productivity growth in 1973. As a result, he dismisses arguments about modest timing discrepancies.

Englander and Mittelstadt [12], writing for *OECD Economic Studies*, however, also dismiss energy as a prime cause of the worldwide productivity slowdown. They find a high elasticity of substitution between energy and other factors of production in OECD countries, excepting Japan where there was evidence of complementarity between energy and capital in the seventies and early eighties.

In sum, there is debate about the effects of the sharp run-up in oil prices on productivity growth. The Griliches-Jorgenson arguments seem most compelling, however, and the rise in oil prices seems to have almost certainly played some role in the productivity slowdown.

Environmental Protection Regulations

Governmental regulations, environmental and otherwise, have also been thought to contribute to the U.S. productivity slowdown,⁴ although as with

⁴ Discussion here is based upon output as normally defined. Some economists argue that clean air and clean water are themselves goods that should be included in output. If so, the discussion in this section should be made part of the section on measurement error.

oil prices, the extent of their contribution is under debate.

A 1986 study by Anthony Barbera and Virginia McConnell [5] found that estimates of the aggregate productivity decline in the 1970s resulting from environmental regulations ranged from 0.1 to 0.35 percentage points annually. The study found the largest effects of pollution abatement regulations in the chemicals; stone, clay and glass; and primary metals industries. Along the same lines, a 1983 study by Frank Gollop and Mark Roberts [13] estimated the 1970 Clean Air Act to have reduced the productivity growth of fossil-fueled electric utilities by 0.59 percentage points per year in 1973-79 period.

A recent study by Klaus Conrad and Catherine J. Morrison [8] examined the effects of mandated pollution abatement investment on productivity in the United States, Canada, and Japan. They found that pollution abatement expenses reduced U.S. productivity growth by 0.223 percentage points in 1973-80. Their results are shown in more detail in Table III.

Depletion of Mineral Resources and Investment Opportunities

William Nordhaus stated in 1982 [19] that about 65 percent of the U.S. productivity slowdown in 1973-79 could be attributed to depletion of mineral resources and investment opportunities. With respect to the depletion of mineral resources, he observed that total factor productivity in mining (principally oil and gas) in the U.S. grew at 2.6 percent annually during 1948-73, then declined at a 2.8 percent annual rate from 1973-79. He also noted that there

had been a break in the trend rate of finding oil and gas after 1973. With respect to a depletion of investment opportunities, Nordhaus cited a dearth of great inventions (telephone, automobile, rayon, airplane, computer, transistor, etc.) in recent years and a decline in patent applications in the seventies.

Whether there has been a depletion in mineral resources seems debatable from the perspective of 1989, although it may have seemed plausible in 1982. The idea of a depletion of investment opportunities, however, seems quite implausible today. As noted earlier, Baily and Gordon observed quite rapid technological progress in the U.S., mainly resulting from the continuing computer revolution.

It is true that patent applications declined in the seventies. In 1970, there were 76,000 patent applications in the U.S. while there were only 59,000 in 1983. This decline does not necessarily indicate an exhaustion of new invention opportunities, however. As Zvi Griliches pointed out,

. . . [patent applications] are heavily influenced by economic conditions and prospects. . . . Patent applications, for example, fell sharply in the 1930s, recovered in the late 1940s, and were essentially flat from the early 1950s through the early 1960s. They rose sharply in the late 1960s and then basically flattened out throughout the 1970s, starting to rise a bit in the 1980s. Most of the rise in patent applications in the late 1960s and early 1970s came from a major rise in applications from abroad which effectively crowded out a significant number of U.S. patents, given the relatively fixed resource level available to the U.S. Patent Office for processing such applications [14, p. 16].

Griliches added that the data on R&D expenditures and the technological news in the daily newspapers do not support the exhaustion hypothesis.

Summary

As is obvious, there are a number of potential explanations for the post-1973 productivity slowdown, and the experts differ on the relative contributions of each explanation. The views of the experts on the contributions are summarized in Table IV.

II.

U.S. PRODUCTIVITY COMPARED TO JAPAN AND GERMANY

The slowdown in productivity growth since 1973, as noted at the outset, has been worldwide. But productivity growth in the United States has also been relatively slower since 1973 than it has been in Germany, Japan, and selected other developed countries, as Table I shows. U.S. productivity growth has been

Table III

	PRODUCTIVITY ^a GROWTH ADJUSTED FOR POLLUTION ABATEMENT EXPENSES	
	1967-73	1973-80
Canada		
Traditional measure		0.229
Adjusted		0.278
Germany		
Traditional measure		2.855
Adjusted		2.963
United States		
Traditional measure	2.661	1.565
Adjusted	2.743	1.788

^a Total factor productivity.

Source: Conrad and Morrison [8, p. 692].

Table IV

**SOURCES OF THE PRODUCTIVITY SLOWDOWN,
ACCORDING TO THE EXPERTS**

Percentage Points Per Year	Reason for Slowing, Name of Expert
0.22	End of shift from low productivity farm and self-employed jobs to higher productivity nonfarm jobs. Denison [10].
0.24	Effects of 1973-75 and 1980-82 recessions. Denison [10].
0.30	Declining labor quality. Baily and Gordon [4].
0.63	Declining labor quality. Jorgenson, Gollop, and Fraumeni [17].
0.20	Measurement error. Baily and Gordon [4].
0.22	Pollution abatement expenses. Conrad and Morrison [8].
1.00	Depletion of mineral resources and investment opportunities. Nordhaus [19].
NA	Rising energy prices. Substantial—Griliches [14], Jorgenson [15], Olson [20]. Modest—Baily and Gordon [4], Englander and Mittelstadt [12].

especially slow relative to Germany and Japan, which experienced trend growth rates in 1979-86 of 2.0 percent and 2.8 percent respectively.

Volumes have been written on the causes of the variances between productivity growth rates in the U.S. and those of Germany and Japan. It is widely recognized, for example, that Germany and Japan have different cultures and their citizens have work ethics that differ from those of American workers. The school systems are different and students are trained differently. The Japanese management style is also different and according to many observers relatively more efficient than the traditional American managerial style. All of these differences are likely to contribute to the variances in national productivity growth rates.

Baily and Blair [2] examined whether the relative slowness in U.S. productivity growth can be attributed to a relative inefficiency of American managers. They observed that when American managers have been able to implement the Japanese team management systems, as in the Toyota-GM NUMMI plant in California, American workers have been able to achieve productivity comparable to the Toyota plant in Japan. On the other hand, they noted that a

number of American managers have had substantial difficulty in implementing the Japanese model. Moreover, they show that criticisms of American management practices extend beyond the automobile industry.

Lester Thurow, the dean of the Sloan School of Management, argues that American managers have failed to commercialize new technologies, pointing to the fact that U.S. companies missed out entirely on the VCR revolution, even though the original technology was developed in the United States. More recently, many companies—in and out of the auto industry—have failed to adopt the Just-in-Time production system developed by Toyota, a system that is much more than a way of saving inventory; it is a cost-saving reorganization of the entire system of production that forces workers to become much more conscious of the quality of each component [2, p. 190].

Baily and Blair were careful to note that the foregoing criticisms of American management practices are not universally shared. Defenders of American management have pointed out that although U.S. exports in the 1980s suffered as a result of the overvalued dollar, export shares of American multinational companies have remained strong. The ability of U.S. owned enterprises to remain competitive throughout this period, the defenders argue, is a sign of healthy management. Also,

... the fact that some U.S. industries have had trouble competing in world markets does not necessarily mean that American managers are deficient overall. For example, there are many industries—including agriculture, chemicals, and package express delivery—in which productivity in Japan is lower than in the United States [2, p.191].

As a result, Baily and Blair concluded that "... the evidence is not definitive in showing either that management quality deteriorated or that management caused the slowdown in U.S. productivity growth" [2, p. 193]. They argued, however, that management practices in the United States still are a matter of concern, for the competitive and regulatory structure in U.S. industry does not provide proper incentives for innovation and productivity improvement. They cited, as a basic description of how American companies deal with competitors, a portion of Michael Porter's book, *Competitive Strategy*:

... in most industries a central characteristic of competition is that firms are mutually dependent. ... In this situation, ... the outcome of a competitive move by one firm depends at least to some extent on the reactions of its rivals. ... Thus success can be assured only if the competitors choose to or are influenced to respond in a non-destructive way [21, p. 88].

As a result of this view of competitors, Baily and Blair argued that American firms have been unwilling to engage in aggressive competition with their

rivals, while Japanese firms have often used aggressive price-cutting tactics. Indeed, they argued that such tactics are typical of Japan's strategy for moving into foreign markets. In contrast, Baily and Blair argued that "... U.S. companies ... have been unwilling to use price-cutting as a form of investment to forestall the entry of rivals" [2, p. 195], believing that "aggressive price competition in the markets for new products will ... sharply reduce the return to innovation by [rapidly] eliminating any return in excess of the cost of production" [2, p. 197]. Baily and Blair also observed, citing U.S. laws against predatory pricing and dumping, that "... opposition to aggressive competition is enshrined in U.S. law" [2, p. 195].

In the past, when Japanese firms relied heavily on technology from the U.S., they were able to avoid the aforementioned trade-off between competition and innovation. Now, when Japan spends heavily on research and development (R&D), Japan meets the challenge of combining competition with innovation by setting government limits on competition. As Baily and Blair put it,

the Ministry of Industry and Trade (MITI) encouraged companies to allocate opportunities for technology development. One company would develop technology aimed for one part of the market, while another firm aimed at another part. This process increased the overall efficiency of R&D by reducing the duplication of research efforts and by allowing innovators to gain at least a temporary monopoly. ... Equally significant, Japanese companies have been able to appropriate more of the return to their R&D by directing a greater share to the development of new processes than their U.S. counterparts—... it is easier to keep the details of a new process secret (and thus to keep technological developments from flowing back to the U.S.). ... Finally, in situations in which Japanese groups have successfully limited their domestic competition, perhaps with help from MITI, companies have been able to earn their target return on R&D at home. But then the government encourages Japanese companies to compete abroad [2, p. 199].

Baily and Blair concluded that the United States could learn important lessons from Japan's treatment of returns to innovation. They argued that U.S. anti-trust enforcers should learn that bigness is not in itself bad. They also observed that Japan has found that aggressive competition in world markets has greatly encouraged cost cutting and quality enhancement. On the other hand, they did not advocate that the U.S. government allocate research initiatives among competing companies, observing that the costs of a misdirected industrial policy can be very high indeed.

Rohlen [22] compared Japanese and American school systems and noted that a higher percentage of students in Japan graduate from high school and that scores on achievement tests indicate that Japanese students have higher language and math

skills than American students. And Murname observed that

recent studies comparing the mathematics skills of American middle-class children with middle-class children growing up in Japan and Taiwan indicate similar skill levels among first graders, but markedly lower performance by American fifth graders [18, p. 227].

Other sources of the United States' productivity lag might include the relatively higher rates of overall investment in Germany and Japan, the relatively more rapid growth of nondefense R&D investment in those countries, the effects of more stringent pollution controls in the United States, and relatively more measurement error in the U.S. data. Tables III and V provide information relevant to these possibilities.

Chart 3 shows private fixed investment as a percent of GNP in Japan, Germany, and the United States. The chart shows that the U.S. figure is persistently smaller. Table V shows that total U.S. R&D spending as a percent of gross domestic product⁵ (GDP) has been relatively high in comparison to other countries. The U.S.'s 2.83 percent in 1985 led all others shown. A more relevant statistic, however, may be the *nondefense* R&D spending as a percent of GDP. According to that statistic, the United States spends a substantially smaller percentage of its product on R&D than either Japan or Germany. As Table VI shows, Japan had almost four times the number of U.S. patent applications in 1983.

Table III provides estimates of productivity growth adjusted for mandated pollution abatement investment. The table shows that measured U.S. produc-

⁵ Gross domestic product is market value of output produced by factors of production *located* in a country. By comparison, gross national product (GNP) is the market value of output produced by factors of production *owned* by citizens of a country.

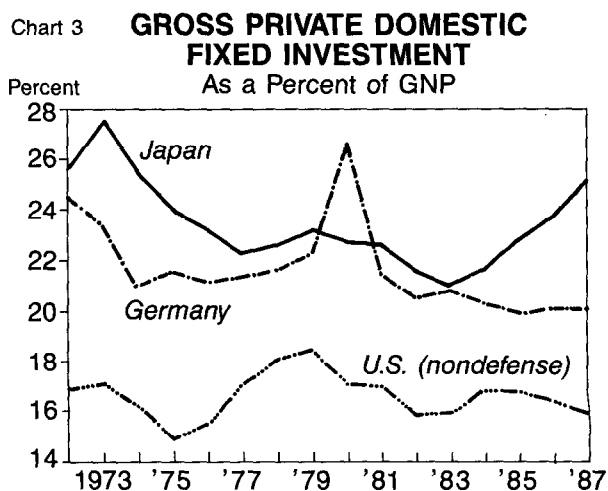


Table V
**RESEARCH AND DEVELOPMENT EXPENDITURES
 AS A PERCENT OF GDP**

(Selected countries, selected years)

TOTAL			
Country	1965	1975	1985
United States	2.76	2.32	2.83
Japan	1.55	2.01	2.61
Germany	1.60	2.24	2.66
France	2.03	1.80	2.31
United Kingdom	2.30	2.03	2.32

NONDEFENSE			
Country	1971	1975	1984
United States	1.68	1.72	1.82
Japan	1.84	2.00	2.64
Germany	2.03	2.10	2.47
France	1.46	1.46	1.79
United Kingdom	1.50	1.32	1.61

Source: *OECD Economic Studies*, Spring 1988, pp. 36-37.

tivity growth would have been 0.223 percentage points higher in 1973-80 had it not been for mandated pollution abatement investment. The table also shows that German productivity would have been only 0.108 percentage points higher per year. Thus,

Table VI
TOTAL PATENT APPLICATIONS

	1965	1975	1980	1983
United States	72,317	76,195	62,098	59,391
Japan	60,796	100,511	165,730	227,708
Germany	38,148	30,198	30,582	32,140
France	17,509	14,106	12,110	11,086
United Kingdom	24,274	20,842	19,710	20,011

Source: *OECD Economic Studies*, Autumn 1988.

the data imply that German pollution abatement regulations had a slightly smaller effect on productivity growth than U.S. regulations.

Finally, there is a possibility that productivity is measured more poorly in the U.S. than it is in Japan and Germany. The author has seen no study of Japanese and German data comparable to the Baily and Gordon study of productivity measurement in the U.S., but there is no reason to believe that the Japanese and Germans would ignore airline discounts, and allow for no quality improvements in construction. More significantly, the difficult measurement problems for productivity statistics stem from measurement of the productivity of services. Chart 4 shows construction, transportation, and services as a percent of GDP in the United States, Japan, and Germany. The chart shows that a substantially larger portion of U.S. GDP stems from those sectors—sectors in which productivity is more likely to be mismeasured. For this reason, U.S. productivity data probably contain relatively more measurement error.

III. CONCLUSION

The conclusion is that there is not any one cause of the U.S. productivity slowdown. Nor is there a single explanation of the slowness of U.S. productivity growth relative to other countries. Based on the research surveyed in this article, however, one can make educated guesses on the relative importance of some of the factors.

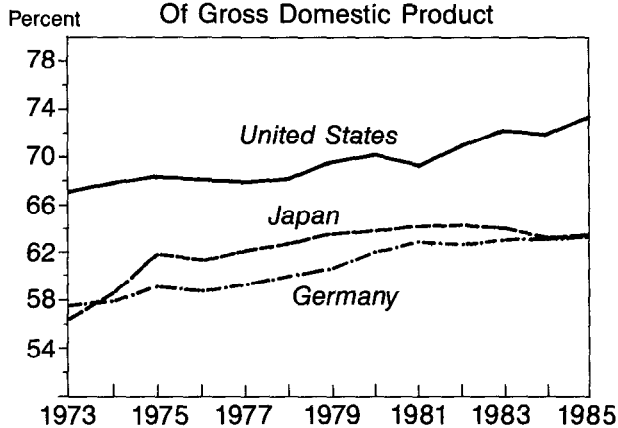
What contributed to the measured slowdown in U.S. productivity growth? Oil prices? Very likely. Mismeasurement? Very likely. Government regulations? Probably. A decline in labor quality? Perhaps.

Depletion of mineral resources? Doubtful. Depletion of investment opportunities? Doubtful.

What causes the U.S. to lag behind Japan and Germany in productivity growth? Cultural differences? Undoubtedly. Relatively less nondefense R&D spending? Probably. Relatively less capital spending? Probably. Differing governmental industrial policies? Possibly. Relatively poorer labor quality? Possibly. Relatively more measurement error? Possibly. Inferior management practices? Possibly. More stringent governmental environmental protection regulations? Maybe.

Chart 4

**CONSTRUCTION,
SERVICES & TRANSPORTATION**
As A Percent
Of Gross Domestic Product



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