may or may not be substance to these allegations. We'll have to see."

Said Hawkins, "I want to look into the politics of cancer." She suspects, for example, that researchers resist sharing results, an opinion based on phone calls she has received since a short news item appeared in *Newsweek* that she planned to investigate the NCI.

When asked about her background in cancer, Hawkins said she reads as much as she can about it—"both facts and rumors." She also pointed out that she has collected money for cancer research in her own neighborhood in Florida. She plainly acknowledges that she is unschooled in the workings of the $1.9 billion cancer institute and its wide array of divisions and programs. Her two aides working on the project are also new to the Washington scene but bring legal experience to their work for the subcommittee. One was a trial attorney in Houston and the other was chief of felony prosecutions for the Florida state attorney's office.

Hawkins said she also plans to review the Occupational Safety and Health Administration at some point. Like the rest of her Republican colleagues, she is worried about overregulation.

The new investigations subcommittee has no budgetary authority, but it clearly has the power to bring the attention of Congress and the press to bear on matters that it chooses to look into. As a freshman senator and new subcommittee leader, Hawkins has chosen an ambitious first project.—MARJORIE SUN

Is R&D the Key to the Productivity Problem?

As new Administration seeks to spur economic growth economists can offer a diagnosis of what went wrong

Is lagging investment in research and development responsible for the decline in U.S. productivity and, therefore, an important contributor to inflation?

The consensus among a group of economists who specialize in studying productivity, technological change, and the dynamics of economic growth seems to be that the decline in R & D spending deserves a share of the blame but, to the extent that such things are measurable, not the major share.

The question is pertinent now. For, as the Reagan Administration seeks to carry out the voters' mandate to fix the ailing American economy, it will soon have to come to grips with the problem of lagging productivity. And the new Administration, like the Carter Administration before it, will have to ask what role, if any, the government should take in promoting R & D.

The experts offer no easy answers. The reasons for slowed growth are complex, and the measurement techniques used have limitations. But the economists do provide solid clues to what went wrong.

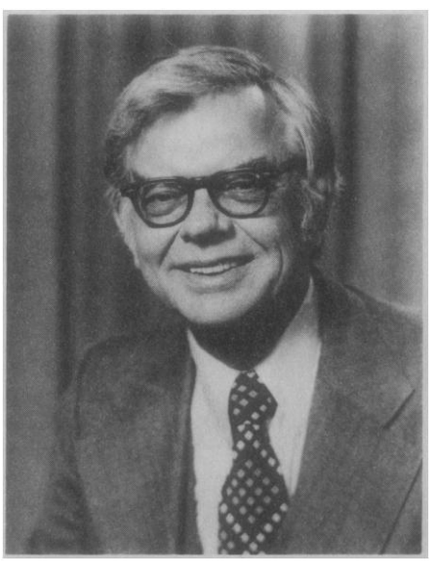
For a broad perspective, the economic strategist can consult the work of economist Edward F. Denison, a leading practitioner of what is called "growth accounting." Denison, a senior fellow emeritus of the Brookings Institution, is now associate director for national economic accounts of the Commerce Department's Bureau of Economic Analysis. A Denison study published in 1979 by Brookings is perhaps the most comprehensive attempt available to do what its title indicates—*Accounting for Slower Economic Growth*. In a recent interview, Denison said he believes his 1979 diagnosis still holds true.

Denison is one of those who does not think that the decline in support of R & D sufficiently explains the downturn in growth. He does, however, see investment in R & D as an important component of growth in the long run. As for identifying the sources of the sharp drop in growth rates in the 1970's, he says they remain something of a "mystery." But he suggests that the blame lies with a cluster of hard-to-measure factors, including R & D, where everything seems to have gone wrong at once.

The big trends are clear. Growth in U.S. productivity averaged 2.4 percent a year between 1948 and 1973. Then a sharp change occurred. Denison notes that national income per person employed dropped by a total of 5.6 percent in 1974 and 1975. It then recovered somewhat, but Denison estimates that its overall growth rate between 1973 and 1978 was zero.

A slowdown in the growth of productivity—measured in output per worker per unit of time or in output per unit of input—had actually begun in the middle 1960's. Denison says this slowing was in part the result of developments that were inevitable, even welcome. These years effectively marked the end of a long period of transfer of workers from agriculture to nonfarm jobs; the pool of farm workers was depleted. Great numbers of young workers and adult women entered the work force, increasing the proportion of inexperienced workers and adversely affecting productivity. Costs of government regulation to protect health, safety, and the environment also began to affect productivity.

Denison finds the change in the growth pattern after 1973 more disturbing and



Edward F. Denison

more puzzling. The sharp drop in productivity growth cannot be accounted for by the developments noted above. Nor, says Denison, are the causes to be found in the recession and drop in capital investment that followed OPEC oil price rises or in such variable factors as weather or work stoppages. Denison suggests that the main "sources of degradation" lay with another group of determinants. These he calls "advances in knowl-

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edge," including R & D, and a number of miscellaneous factors.

Advances in knowledge are not only derived from R & D. The category includes "technological knowledge," which Denison defines as "knowledge concerning the physical properties of all things and how to make, combine or use them in a physical sense. It also includes managerial knowledge—knowledge of the business organization and managerial techniques construed in the broadest sense."

Denison calculates that, between 1948 and 1973, some 1.4 percent or more than half of the 2.6 percent average annual increase in productivity was attributable to advances in knowledge and miscellaneous causes. After 1973, these sources contributed virtually nothing to productivity growth. Determinants in this group are particularly hard to calculate separately and are not broken down individually in Denison's analysis. He lumps them together, terming them a "residual," in contrast with determinants, some of which were mentioned earlier, that can be independently measured more readily. Most of this output data is drawn from the national income product accounts of the Bureau of Economic Analysis.

On the list of elusive miscellaneous causes were some effects of government regulation and taxation, and the impact of changing attitudes toward work, of a decline in quality of management, of shifts of workers to service industry jobs where productivity is lower than in manufacturing, and of rises in energy prices.

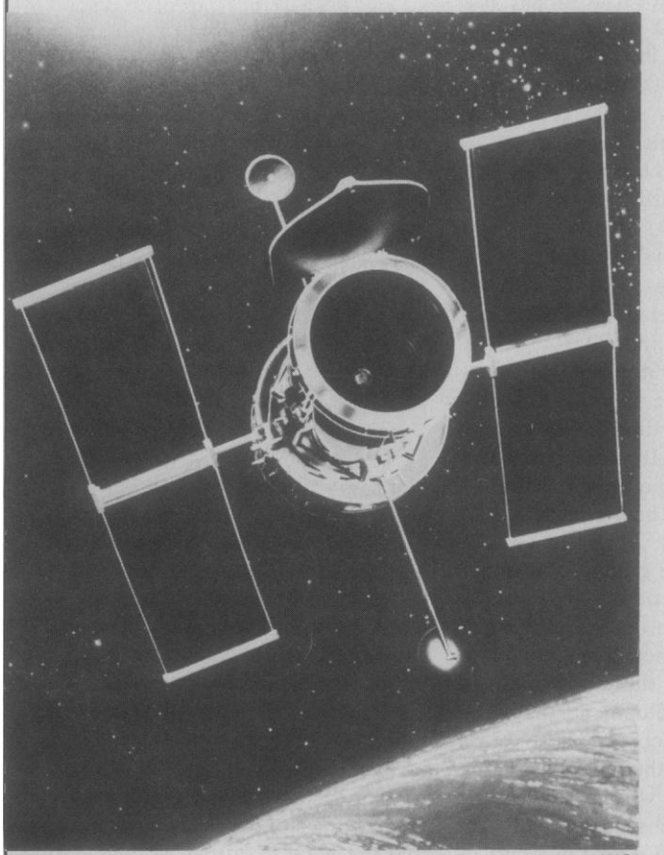
Why did the contributions to productivity of the residual suddenly turn negative? Says Denison, "What happened is, to be blunt, a mystery." He thinks a slowdown in the introduction of new knowledge into the productive process may have influenced the change. The lower proportion of the national product devoted to research may also have been a factor. But he surmises that the sudden drop is "due to one or more of the miscellaneous determinants."

If that is the case, should not the rise in energy prices be the prime suspect?

Space Telescope Institute at Hopkins

The choice of Johns Hopkins University as the site for a new Space Telescope Science Institute will make the Baltimore campus home base for astronomers using the space-borne telescope that promises to give them a penetrating new look at the universe.

The institute will serve the National Aeronautics and Space Administration's billion-dollar orbiting observatory project whose centerpiece is an optical telescope with a 96-inch mirror. NASA's space shuttle, a partly reusable space vehicle, is scheduled to put the telescope and its spacecraft in orbit 360 miles from the earth in 1985.



NASA

Artist's concept of Space Telescope in orbit

Hopkins was the site nominee of the Association of Universities for Research in Astronomy (AURA), one of several astronomical consortia that competed for the institute. The selection, announced on 16 January, was made by NASA administrator Robert A. Frosch after considering a report by a source evaluation board made up of government experts.

The AURA-Hopkins proposal is said to have won a close decision over one by Associated Universities, Inc., of Washington, D.C., that backed Princeton as the site for the institute. AURA, a 14-university consortium, manages other astronomical facilities including observatories at Kitt Peak, New Mexico, and Cerro Tololo, Chile.

Arthur C. Code of the University of Wisconsin has been named acting director of the institute and several Hopkins faculty are temporarily filling top staff jobs while an AURA committee searches for permanent officers.

AURA now enters negotiations with NASA on a contract to establish and operate the institute. To accommodate it, Hopkins has agreed to build a five-story building costing an estimated $6 million. Costs would be recovered through a "lease back" agreement.

AURA's contract with NASA for the initial 5 years is put at about $24 million. Added funding will be needed for support of visiting astronomers and an archival research program. These funds will be sought through grants from science agencies. The annual operating budget when the institute is in full swing is estimated at $8 to $10 million.

Permanent staff of the institute is expected to number 150, including 40 astronomers. Some 200 other astronomers are expected to visit the institute each year to make observations and analyze data.

The institute will be located on the Hopkins main Homewood campus. Its proposed building will have a large display area as well as offices for permanent staff and visitors and computer and observation facilities. Computers and

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Denison himself notes that the timing of the sharp break in the contribution to productivity in 1973 should be a clue. The drop in the residual series coincides with the oil price rise and its immediate aftermath. However, basing his judgment on the research available, Denison wrote, "I do not think that most of the productivity slowdown can be ascribed to energy prices."

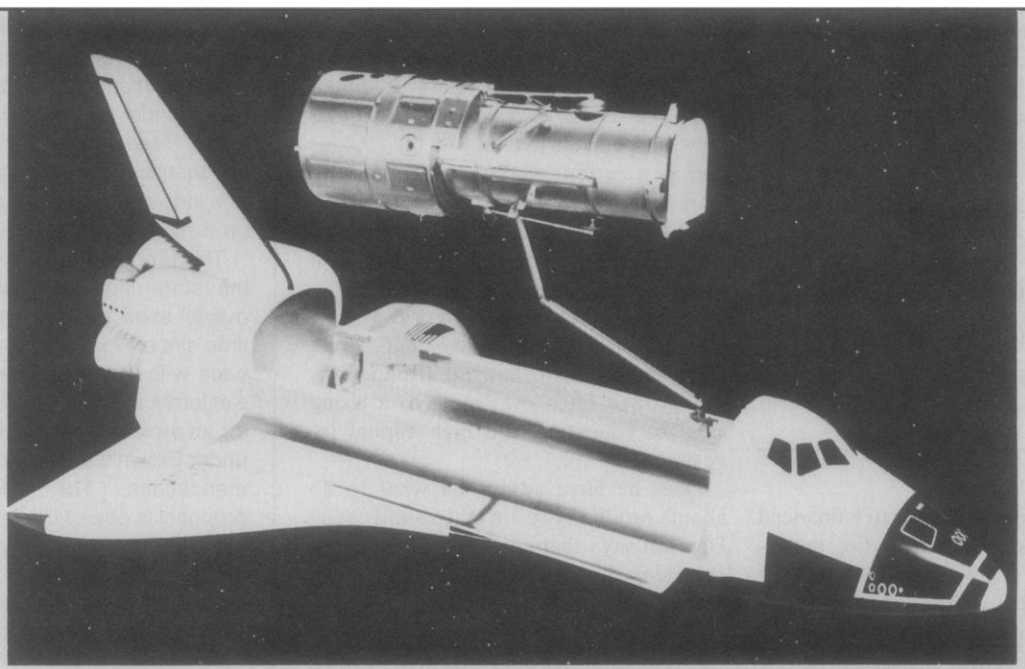
He notes that the effects of the energy price rise were cushioned by such things as government intervention and the reaction of business in using less energy per unit of labor, capital, and land. He acknowledges that other economists have calculated a more substantial impact from energy price increases, and regrets that relatively little research has been done on the subject. He says that "Pending such research, the estimate that the energy price increase reduced the growth of my residual by about 0.1 percent a year from 1973 to 1978 seems reasonable."

Rejecting any "single hypothesis" to explain the sharp change after 1973, Denison says, "It is possible, even probable, that everything went wrong at once among the determinants that affect the residual series."

Denison's comments on R & D give mild support to proponents of the view that investment in R & D by industry and government is a vital determinant of productivity growth.

No dramatic drop in R & D funding occurred around 1973. As a percentage of the gross national product, spending on R & D declined more or less gradually from a peak of 2.97 percent in 1964 to 2.27 percent in 1976 and 1977. In terms of constant 1972 dollars, expenditures on R & D peaked at $29.8 billion in 1966 and then, until 1976, spending remained essentially flat. The portion of R & D funded by the federal government sagged in the early 1970's but began to recover in 1976.

In gauging the contribution of R & D to productivity, Denison says that he starts with an estimate by Zvi Griliches of Harvard which indicates that before the 1973 slowdown, R & D contributed,



NASA

Space Shuttle will launch NASA's Space Telescope into orbit

special data reduction equipment will be procured by NASA.

The institute will have a "hardwire" data link to NASA's Goddard Space Flight Center at nearby Greenbelt, Maryland, where controllers at a space telescope support center will be able to point the telescope. Data from the telescope will be transmitted by telemetry data relay satellites in geosynchronous orbit to a NASA communications center at White Sands, New Mexico, then by Comsat to Goddard and on to the institute for processing.

The institute will function in ways that are analogous to a national accelerator laboratory as it takes on responsibility for reduction of data, selecting observers, and ensuring the scientific performance of the telescope.

The telescope itself, scheduled to be ready a year before the 1985 launching, will cost an estimated $700 million to $750 million. Prime contractor for the optical telescope assembly is the Perkin-Elmer Corp. and, for the support system module, Lockheed. The space telescope project is a joint undertaking by NASA and the European Space Agency, with ESA a one-sixth financial and scientific partner in the venture.

The space telescope survived a tough funding decade for NASA, being scaled down by roughly one-third and scraping through episodes when it was nearly knocked out of the budget (*Science*, 13 February 1976). If the investment is substantial, the scientific dividends are expected to be rich. Freedom from the earth's distorting atmosphere and the telescope's stability and capacity for high resolution are expected to enable it to "see" objects 50 times fainter than can ground-based telescopes.

The initiative for making Hopkins a candidate site for the institute came from AURA. Hopkins' propinquity to Goddard was a main attraction. But a whole-hearted effort by Hopkins administration and faculty to land the institute seems to have helped materially to carry the day. The result is that Hopkins is about to be launched into the astronomical big time.—JOHN WALSH

at most, 0.3 percentage points a year to growth, and probably less.

Denison wrote that the "change in R & D spending from the 1966 rate to the 1970 rate might reduce its contribution by 0.1 percentage points with the effect perhaps delayed until the mid 1970's. The range of 0.0–0.1 percentage points cover the probable change in contribution." Denison acknowledges that some other economists put the contribution higher and attributes this to differing estimates of various factors.

Denison and others note that there are special difficulties in calculating the impact of R & D. What is being measured are changes in output per unit of input, and only some kinds of advances in knowledge are measurable in this way.

Improvements in production processes are most readily measurable. New products, on the other hand, don't show up as reducing unit costs. According to Denison, "Nearly all federally financed R & D is in this category and so

> "What happened is, to be blunt, a mystery."

is the larger part of industry-financed R & D. Only R & D that is directed either toward new process, which may be roughly identified with research to reduce a firm's own costs, or toward new *intermediate* products and capital goods, has an objective that, if achieved, raises measured output per unit of input."

In a recent article, "R & D and the productivity slowdown,"* Griliches suggests some explanations for the apparent collapse of R & D's contribution to productivity growth. One possibility is that "much of the effect of past R & D is embodied in new equipment, and a slowdown in capital growth may also induce a decline (a postponement) in the effect of R & D on productivity."

For a general answer to the puzzle of the collapse, Griliches says, "The most likely explanation is one of confusion: the large energy price shocks, the resulting fluctuations in capacity utilization, the substantial increase in uncertainty about future absolute and relative prices may have forced many firms away from their long-run production frontier."

Griliches writes that "The other point to remember is that even though the measured effects of R & D on measured productivity may be small, its true effects may be quite a bit larger. First, we have yet to learn how to measure the spillover effects of R & D within and across industries. Second, much of past and current R & D is spent on socially valuable activities such as our health and the health of our environment, items that are not valued positively in the national accounts as currently constituted. Finally, R & D is a chancy and fickle process. Even if it has run into a dry spell, this does not imply that the current expenditures may not have future returns or that there are no major productivity returns on the drawing boards."

If the case for R & D is somewhat better than the input-output analyses show, what are the implications for economic policy? Asked what he thinks could be done to improve economic growth, Denison lives up to his reputation as a careful analyst who takes the long view.

He cautions that "growth rates are almost glacial." The nearly 3 percent a year average increase in productivity in the quarter century after World War II was historically unusually high, says Denison. He says that the strong postwar growth rates owe most to a rising level of education and high capital investment.

Does he have advice on what to do about productivity in the short run? Denison says that considering the sharp change in the growth rate, "I would not know how to put together a package to get you back to the growth rate we had."

What about more government support of R & D? Although Denison says that R & D is probably not responsible for much of the productivity retardation, he is on record as thinking that R & D is "a promising way of promoting future productivity." He notes that in the context of growth rates, a yield of even a tenth of a percent a year in growth in productivity from a particular source over 10 years is "not bad."

Denison says he is impressed by the studies of Edwin Mansfield of the University of Pennsylvania and others indicating a high social return from investment in R & D. Denison thinks that the inability of individual firms to recapture more than a fraction of the return on their R & D investment provides a justification for increased government support of R & D. "If the government is going to subsidize anything," he says, "I'd put R & D high on the list."

—JOHN WALSH

American Economic Review, May 1980.

Governor Brown Boosts Microelectronics

A novel plan to pump up to $10 million a year into microelectronics research at the University of California, Berkeley, has been cooked up by Governor Edmund G. Brown, Jr., university officials, and local industrialists. The plan, outlined last month in Brown's state budget message, seeks to involve the California semiconductor industry in both the planning and the funding of microelectronics research at Berkeley.

The idea is to set up a microelectronics research center in the university's electrical engineering department, with an injection of $2.6 million of state funds for facilities and equipment. Research at the center would be financed jointly by the university and industry, with each side providing up to $5 million a year.

The proposal, which is now before the state legislature, is part of an overall state budget that, for the first time since World War II, will not keep pace with inflation. The University of California system, for example, is due for an increase of less than 4 percent under Brown's austere budget recommendations. The microelectronics proposal is one of the few new spending initiatives in the entire budget, and if approved, the center would be the largest joint industry/university research unit of its type in the country.

According to plans worked out between Brown's office, the university, and representatives from semiconductor companies, research would be funded at the proposed center on a project-by-project basis. Projects approved for state funding would be able to go ahead only if an industrial sponsor could be found to come up with matching funds. Overall policy for the center would be set by a board, appointed by the president of the University of California from nominees submitted from the university, the governor, and industry.

Brown has explained the proposal as a measure designed to help a key California industry to fend off competition from outside the state. In the past decade, the electronics industry has become a powerful economic force in California. It accounts for one-fourth of all the new jobs generated in the

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