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ECONOMIC POLICY IN THE FACE OF DECLINING PRODUCTIVITY GROWTH

William D. Nordhaus

September 1981

ECONOMIC POLICY IN THE FACE OF DECLINING PRODUCTIVITY GROWTH

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The recent slowdown in productivity growth constitutes the major economic ailment of modern industrial countries today. More than any other ill-- higher oil prices, deteriorating terms of trade, volatility of financial or foreign exchange markets, high inflation-- low productivity growth is the root of the arrest of growth in living standards as well as the political malaise in the West.

Faced with this ailment, there has been no shortage of prescriptions --most of them self-serving. But the central question for economic policy has not been carefully analyzed:

How should we react to slower productivity growth? Should we save more? Should we work harder? Or should we lay back a bit and enjoy our endowment from the past?

While the sources of the productivity slowdown have been extensively analyzed, little analysis of policy response has followed.

(1) the author is John Musser Professor of Economics, Yale University, and a member of The Cowles Foundation. Version 6.25.81.900.

Surely there should be a better link between diagnosis and prescription. It is as if, upon seeing a neighbor jog his rounds more slowly than usual, we give him our expert advice without finding out why. But, surely, our advice to our neighbor must depend on the source of his lagging pace. Perhaps his shoes are old and pinch his feet, in which case we would recommend a program of modernizing his jogging equipment. Or, instead, has he grown somewhat fat, in which case a period of dietary austerity is in order? On the other hand, if his strength is depleted, it might be suicidal for him to run faster.

My theme here is similar. The possible reasons for the productivity slowdown in industrial countries are numerous. How we should respond depends on what has happened. A more serious example is the decline in productivity in extractive industries. 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 2.8 percent annually from 1973 to 1979. A very clear break in trend of finding rates for oil and gas can be seen in the U.S. after 1973. What was the source of the productivity break in oil drilling in 1973? There are two classes of reasons--manmade obstacles and natural depletion. In the former category we would place the results of the regulatory apparatus set up around 1970 to control oil and gas prices and regulate mine safety. In the depletion category we might guess that the dramatic upturn in drilling since 1973 has led to severe short-run diminishing returns.

Although the oil drilling story is fascinating in itself, I tell it here only to illustrate the more general point. How we should respond to the productivity drop in extraction depends crucially on which of the two explanations in the last paragraph we believe. If we think manmade impediments (price controls, high or distorted taxes, confusing regulations) are to blame, then we should work overtime to rationalize or dismantle these obstacles. If, on the other hand, we feel that we have been dealt a poor hand by nature in the 1970s (depletion of resources, declining inventiveness, low marginal productivity of capital), then the appropriate response is less clear. Upon seeing that the yield per well drops sharply, do we want special tax incentives for investment or saving to induce us to drill more wells? Or should we drill less and use the freed resources to develop synthetic fuels or to enjoy solar intensive beach activities? There is no clear answer. Some old joggers try harder while others turn to gin.

With these introductory notions, I now turn to a discussion of the productivity puzzle and policy reactions. The first section reviews evidence on the sources of the productivity slowdown in the United States and other major OECD countries. The second section discusses economic policy responses from an analytical point of view.

A. SOURCES OF THE PRODUCTIVITY SLOWDOWN

The purpose of the present section is to review the recent discussion of the productivity slowdown in the United States and major industrial countries.(2) Has there really been a productivity slowdown? Is it unprecedented in recent economic history? What are the generally accepted reasons given for its occurrence? And how do the reasons given fit into the depletion versus obstacle theories given above?(3)

1. Has there really been a productivity slowdown?

It is by now generally accepted that the productivity growth in the United States has significantly slowed over the course of the 1970s. There is no consensus about the exact timing of the slowdown; productivity growth has clearly slowed since the early 1960s, but whether the decisive year was 1969 or 1973 is subject to dispute. In what follows we will use the year 1973 as the break year because a distinct break shows in the data that year, and many prominent reasons for the slowdown (energy prices being the outstanding example) appeared in 1973.

Using 1973 as a break point, Table 1 gives several measures of aggregate productivity performance in the earlier and later period. The decline in the growth of labor productivity is clear for all concepts used. Depending on which concept is used, productivity growth has fallen by 1.9 to 2.3 percentage points per annum.

(2) I will use the inaccurate "productivity slowdown" as shorthand for "a decline in the growth rate of labor productivity."

(3) The section on sources of the productivity slowdown draws on a fuller discussion in Nordhaus (1980).

Table 1.

Measures of productivity performance, United States
before and after 1973

[Annual average growth rate, percent]

	<u>1948-73</u>	<u>1973-80</u>
<u>Output per hour</u> <u>of all persons:</u>		
Total economy	2.3	0.4
Private business	2.9	0.6
Nonfarm private business	2.5	0.5

Source: Economic Report of the President, 1981.
Figure for total economy is real GNP
divided by total employment.

It should be noted that the productivity decline is also extremely widespread. Table 2 shows the growth of total factor (capital and labor) productivity in major industries in the U.S. Of the 12 major industry groups, only communications and the finance, insurance, and real estate group have not suffered a slowdown in the post-1973 period.

At a somewhat deeper level, we might ask whether the productivity slowdown is an illusion. After three days of continuous rain we do not generally dust off plans for building an arc-- although after thirty we might. To what extent is the half dozen years of dismal productivity growth sufficient to convince us that, to return to our climatic analogy, we have encountered a technological climate change rather than a run of storms.

To my knowledge, no one has looked hard at the question of whether the recent productivity slowdown has a precedent. For this reason, I patched together a long time series on labor productivity in the nonfarm business sector of the U.S. running over the period 1909 to 1979. Using standard techniques I removed the cyclical influence on productivity, and then asked a number of questions about the past behavior of the cyclically corrected series.(4)

(4) The cyclical influence was removed as follows: A regression of productivity change on output growth and lagged output growth was run; the coefficients and standard errors being .316 (.044) and -.077 (.044) respectively. A cyclically corrected productivity growth was then constructed by subtracting from measured growth the deviations of output growth from its mean times the estimated coefficients. Note that the sum of the coefficients is about 0.25, indicating that faster growth leads to faster productivity growth in the long run. While this extent of economies of scale is high, it is not entirely out of line with estimates of Denison or Kaldor.

Table 2.

Total Factor Productivity Growth in
Major Industry Groups, United States

	<u>1948-73</u>	<u>1973-79</u>
Agriculture	3.2	1.4
Mining	2.5	-3.0
Construction	1.2	-2.3
Manufacturing	2.2	0.8
Transportation	2.8	0.6
Communication	4.6	4.6
Public Utilities	4.1	-1.6
Trade	2.4	0.2
Finance and Insurance	0.2	0.9
Real Estate	2.8	2.9
Services	1.8	-0.1

Source: American Productivity Center (1980).

First, we can simply inspect the time series on productivity growth. The most revealing series, shown in Figure 1, is the long time series on smoothed, cyclically corrected productivity growth. For this series, I chose a six year lagging average (corresponding to the six lean years since 1973). The last observation (for 1979) thus corresponds to the average productivity growth over the period 1973-79.

The results are quite striking. If we ignore the wiggles, there was more or less constant rate of productivity growth from World War I to the middle 1960s. Starting about 1966, however, there has been a slow but steady downward creep from an average of 2 to 2 1/2 percent annually to a level of slightly under one percent in 1979. Moreover, the smoothed rate of productivity growth in 1979 was lower than any year since 1933, and one would have to go back before 1920 to find a markedly worse year. The only year remotely as poor in the postwar period was 1951. Thus casual evidence indicates that one would have to go very far back--to a period which surely stretches credibility about the data-- to find comparable poor experience.

A second way of examining the data is to perform a formal statistical test on the hypothesis that there was a change in structure after 1973. To do this, we simply take our regression described in the footnote (4) above and add a dummy variable to the post-1973 period. This technique gives results that are consistent with the visual impression in Figure 1. When the test is confined to the postwar period (1949 to 1979) there is a statistically sig-

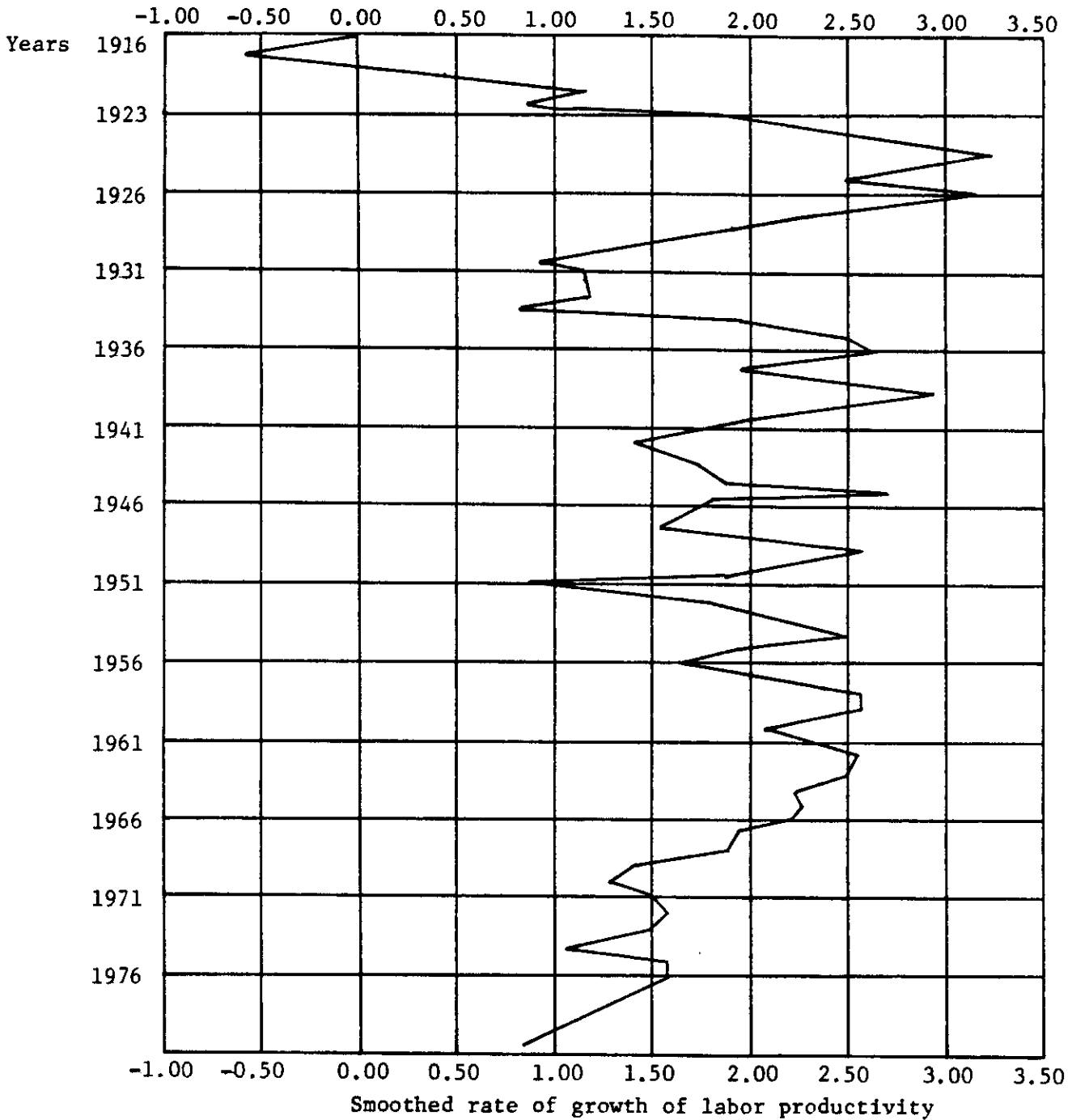


FIGURE 1. Estimated long-term growth of underlying productivity growth. Series is output per worker-hour in the private non-farm business economy. Cyclical influence has been removed as described in footnote. For each year the rate is the average of the cyclically corrected growth over the last six years. The last observation, therefore, is the average cyclically corrected productivity growth rate over the period 1973-79.

nificant decline in productivity (the dummy shows slower productivity growth by 1.3 percent with a standard error of .63 percent). However, if the entire period is weighed (1912 to 1979), the slowdown is smaller (.98 percent) and has a larger standard error (1.0 percent). Thus, while the slowdown may look quite unprecedented for those with short memories, in the longer view, the slowdown is one which we would expect to occur from time to time. Indeed, such slowdowns have occurred twice before in the last 60 years. Judging on the basis of the postwar period, we would expect to draw a hand as bad as that of the last 6 years once every 4 decades. Over the entire sample period, we would expect as bad a hand about once a decade.

The productivity slowdown has also been felt in all the major industrial countries. Illustrative data can be gleaned from studies by the OECD Secretariat. More than the usual caution is necessary in relying upon these data, for they have different sectoral and conceptual bases.

Table 3 shows the productivity trends in the seven largest industrial countries; while Figure 2 graphs these for the two sub-periods. As is customary, we examine the periods before and after 1973. The results are as striking for the other industrial countries as for the U. S. Productivity has slowed markedly in all countries. Japan showed the largest slowdown, a 5.2 percentage point deceleration, while Germany's is the smallest, slowing 1.2 percentage points. By international standards, the slowdown in the United States was relatively modest.

2. Why has productivity slowed?

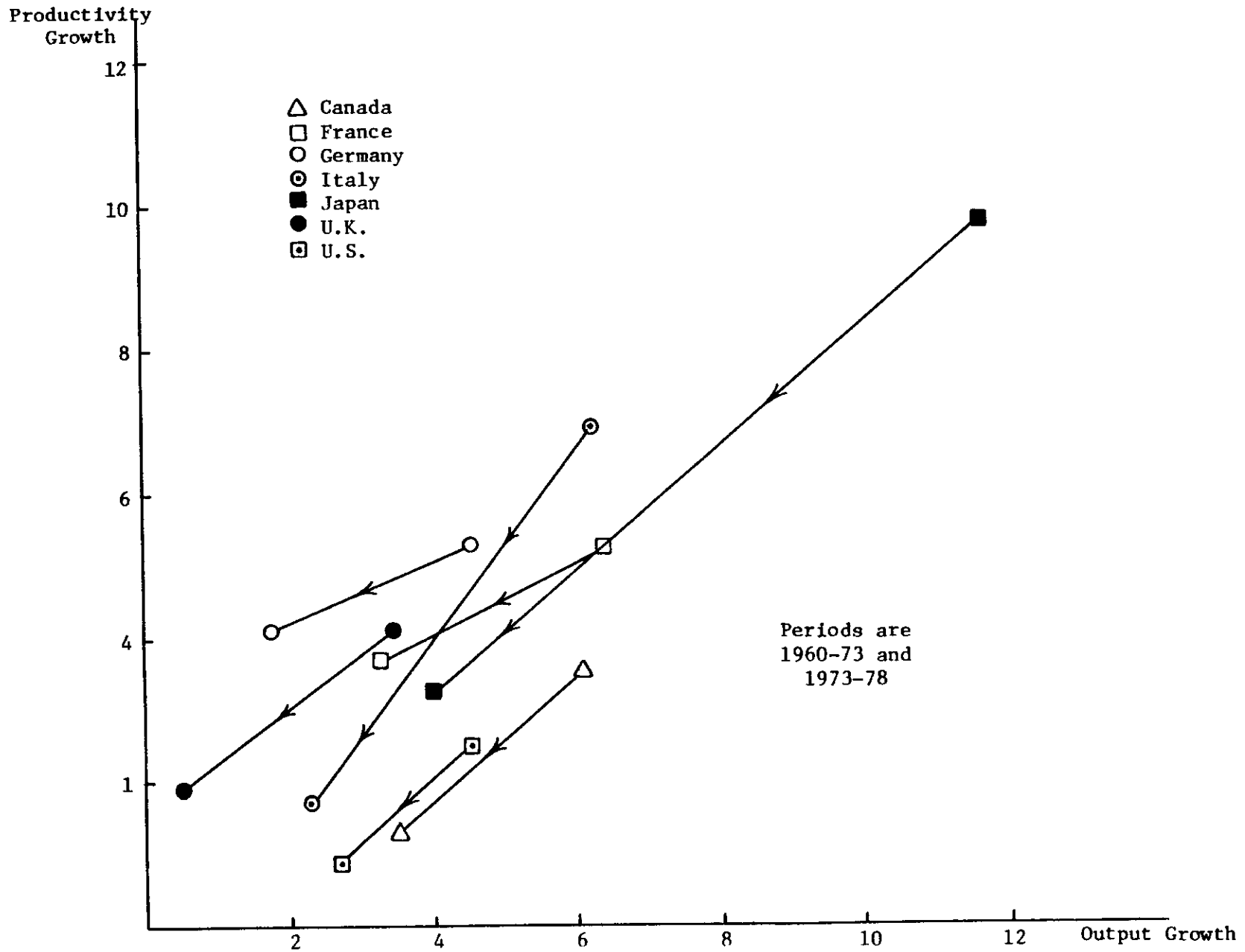


FIGURE 2. Productivity and output growth in seven largest industrial countries, 1960-73 and 1973-78.

Source: Table 3.

Table 3.

Labor Productivity Growth in Major OECD Countries.Non-farm Business Sector
(average annual growth rates)

	<u>1960-73</u>	<u>1973-78</u>
Canada		
Output	6.0%	3.4%
Productivity	3.5	1.3
France		
Output	6.3	3.3
Productivity	5.2	3.7
Germany		
Output	4.6	1.7
Productivity	5.3	4.1
Italy		
Output	6.2	2.2
Productivity	6.8	1.7
Japan		
Output	11.7	4.0
Productivity	8.5	3.3
United Kingdom		
Output	3.4	0.5
Productivity	4.1	1.9
United States		
Output	4.3	2.6
Productivity	2.5	0.9

Source: OECD (1980), p. 16.

From now on I will assume that productivity has slowed and turn to the reasons. Almost all studies estimate the effect of a particular factor on productivity growth by "growth accounting." This technique assumes that there is a well-behaved aggregate production function, and that for most factors the contribution of inputs (the marginal product of a factor) is measured by its market return.

While there are many shortcomings to such an approach, it is the only theoretically defensible technique that allows a quantitative decomposition of slower growth. It can only analyze issues that are quantifiable, and thus cannot test hypotheses such as an epidemic of on-the-job laziness or poorly measured output. Thus, just as we are likely on a dark night to start searching for a lost wallet under a lamp post, so a search for lost productivity starts with growth accounting.

The United States

We will not attempt to summarize the studies in any detail at this point, but make general comments about the overall findings. Table 4 shows for the private business economy my "best guess" as to the magnitude and the source of the productivity slowdown for the United States, from Nordhaus (1980).(5)

(5) In what follows, we identify "proximate" causes of the slowdown. That is, if capital growth slowed because of higher energy prices, the "cause" of the slowdown will be identified as capital rather than energy. This is, again, an accounting exercise rather than a structural model of the economy.

Table 4.

"Best Guess" Sources of Productivity Slowdown*

Total Decline	2.5 percentage points
Cyclical	0.3
Trend	2.2

Sources:

Capital stock	0.3
Labor	0.1
Energy	0.2
Regulation	0.2
R & D	0.1
Sectoral shifts	0.3
Unexplained	1.0

*The "slowdown" is the difference in the growth rate of productivity per hour worked from the period 1948-65 to the period 1973-80. Output is gross product originating in the private business sector. Note that a positive number indicates a slowdown.

It is generally thought that the slower rate of growth of the capital stock has contributed significantly to the productivity slowdown. The severe recession after 1973, as well as a higher cost of capital, led to a markedly lower growth in the capital stock. This would imply that at a given rate of utilization of capital, its contribution to output would be smaller. The best guess as to the contribution of the slower growth of the capital stock to the slowdown is 0.3 percent per annum. In addition, changes in utilization since 1973 have been large, but should be associated with the cycle, not to a deficient growth in capital stock such as might arise with higher cost of capital.(6) These studies omit a further factor, that the profit rate on capital (and presumably the marginal productivity of capital) has declined in recent years.

As the productivity concept we are using here is output per hour worked, the contribution of labor is likely to be small. However some demographic shifts have taken place over the postwar period. The best guess is that labor quality subtracted approximately 0.1 percent annually from conventionally-measured productivity growth.

The contribution of energy to the productivity slowdown is extremely controversial, and is discussed further below. The estimates generally converge on numbers in the range of 0.1 to 0.2 percent per annum, except for models which have an unreasonably rapid

(6) There is a serious problem in many estimates of the contribution of the capital stock. They compound changes in stock with changes in utilization. The latter appears responsible for most of the contribution of capital to lower growth. Assuming the two factors have the same output elasticity is clearly a misspecification.

adjustment of capital stock to change relative prices.

The influence of regulation is perhaps the most difficult effect to measure. The direct effects--inputs devoted to tasks that do not show up as measured output--are easily measured, and the estimates given in Table 4 reflect these direct effects. The indirect effects--chilling effects of regulation on innovation, entrepreneurship, or choice of techniques-- do not appear in the estimates. As a crude calculation for manufacturing suggests the latter may be quite large, I use the high end of the range in estimating the effects of regulation on productivity.(7)

Two other items which have been explicitly identified and measured with some care are the effects of the lower intensity of research and development, and the role of sectoral shifts. It is estimated that these contribute modestly to the productivity slowdown. One of the important features of Griliches' study is the suggestion that the social rate of return on R & D has declined markedly in the most recent period.(8)

A final factor in the productivity slowdown is the effect of slower economic growth since 1973 upon productivity growth. This factor is sometimes ignored, even though there is considerable evidence of short-run (even long-run) increasing returns to scale. Most studies that directly examine this question for the United

(7) The crude calculation examines the extent to which the deceleration of labor productivity in 50 manufacturing industries before and after 1973 is larger than can be explained by direct costs. In work underway with Robert Litan, we find that the total effect is about three times the direct effect, but the coefficient is very poorly determined.

(8) See Griliches (1981).

States find some modest effect of cyclical conditions--ranging up to 0.3 percent for the period 1973 to 1978. It should be noted that the utilization correction discussed under capital above is better described as a cyclical correction rather than a capital contribution.(9) I will use 0.3 percent per annum as a reasonable best guess for the contribution of slower economic growth to slower productivity growth.

Table 4 collects my best guess as to the sources of the productivity slowdown in the private business sector. In this collection, I have used the period up to 1965 and after 1973, because it is so difficult to identify exactly where the break point came historically. For these periods, the productivity slowdown was 2.5 percent. Taking all the identified factors, we can reasonably explain about 1.5 percent of the decline, but the remaining 1.0 percent must at this point be labeled as mystery.

International comparisons

It is customary for American economists to ignore the fact that there are other industrial countries east of Cape Cod and west of Malibu. The experience of others is particularly important given the pervasive nature of the productivity slowdown, as well as the fact that it occurred after 1973--a year in which all industrial economies suffered the trauma of the oil shock and after which fol-

(9) In a statistical test performed for an earlier paper, Nordhaus (1980), I found that the slower economic growth for the private business sector contributed about 0.3 percent to the slowdown after 1973.

lowed a major recession in world trade. To what extent can we resolve some of the debates about the productivity mystery by looking at international data?

The first question is whether we should be interested in pervasive phenomena. Given the universality, simultaneity, and depth of the productivity slowdown, it seems clear that we should look first for common explanations. Among common explanations, five seem plausible: energy, slow economic growth, slow growth of capital, and inflation.

1. The most plausible explanation for a common cause of the slowdown is the energy crisis of 1973. The energy sector is one in which structural change over the last 10 years has been so rapid that it has affected overall economic performance. With respect to the productivity problem, three facets must be recognized. First, the energy industries have experienced an extremely sharp decline in productivity growth. Mining and utilities experienced total factor productivity decelerations of 6 percent over the postwar period. Second, the sharp run-up of energy prices since 1973 led to some substitution of other factors of production for energy, lowering the productivity of these other factors. Finally, the inflationary impact, terms of trade, and real income losses due to the energy crisis contributed to the slower demand growth and concomitant slower productivity growth since 1973.

There is a major controversy as to energy's contribution to the productivity slowdown. The range of estimates of contribution for the United States are from 1.5 percent per annum to 0.1 percent

per annum. Source of these differences arise because one author looks at proximate causes (as in Berndt (1980)) while another looks at ultimate causes (as in Hudson and Jorgenson (1978)). This difference has often been attributed to the energy-capital complementarity question. The issue can be quite succinctly put by considering two polar cases and realistic data for 1973-77. Start with the normal case, where energy, capital, and labor are combined in a Cobb-Douglas production function with shares of 0.1, 0.2, and 0.7 and further where labor supply and real interest rates are exogenous. In this world a 25 percent rise in real energy prices will lead to a long-run decline in labor productivity of about 3.2 percent.

At the other extreme, let energy and capital be used in fixed proportions and combined with labor in a Cobb-Douglas production function. In such a case, doubling of energy prices would lead to a decrease in labor productivity of 3.4 percent. Over a four-year period, with full adaptation of the capital stock, we should find a decline in productivity of 3.5 percentage points. (In a more complete model, Hudson and Jorgenson estimate that the four-year effect was 2.5 percentage points.) Because the exact form of the production function does not make much difference, it is, hard to see how the issue of capital-energy complementarity could generate much controversy.

In fact, this capital-complementarity controversy has been a smoke-screen which effectively camouflaged the real issue--the embodied nature of energy use. The error in both models above was to

assume that the capital stock and energy use adapted instantaneously to changed relative prices, as in the so called putty-putty model. In the first model, energy consumption should have fallen 6 percent annually relative to trend, while in the second it should have fallen 2 percent annually. In fact, in the long run most energy conservation takes place through substituting more energy-efficient refrigerators, houses, and cars--a process whose half-life is probably 20 years. From a statistical point of view, the reason time-series putty-putty models keep telling us that energy and capital are complements is that, by creating a complementary factor of capital and energy, the speed of reaction of energy demand is effectively slowed down from 6 percent a year to 2 percent a year--to a speed closer to the putty-clay model.

The significance of the putty-clay view is that the effect of energy prices on productivity is spread over many years. In a no-growth economy where capital lives 20 years, the Cobb-Douglas putty-clay model would predict that as a result of the 1973 price shock productivity would show an energy drag of 0.1 to 0.2 percent until 1993. During this entire period high cost oil would be progressively replaced with high cost capital and labor. The slower the adjustment, the less the productivity slowdown and the longer is the period over which the productivity drop is spread.

In a recent article in the Brookings Papers, I estimated the impact of the 1973 oil price increases on the productivity slowdown for a simplified putty-clay model.(10) For the OECD as a whole, my

(10) See Nordhaus (1980a)

best guess was that the price-induced response lowered productivity growth 0.14 percentage points per annum over the 1973-79 period compared to a slowdown of 2.4 percentage points from the 1963-73 period

Thus while the oil crisis looks like a highly plausible cause for the slowdown, its quantitative significance appears insufficient to account for much of the slowdown in most countries.

2. Investment

A common theme in popular as well as professional discussions is that the poor recent investment performance in industrial countries is largely responsible for the productivity slowdown. I indicated above the evidence for the U. S. was mixed on this issue, and depends in part on the treatment of utilization of capital.

It is possible to get further evidence by examining international trends in investment behavior. The OECD has collected data on capital stocks in major countries for the years 1960, 1973, and 1978. The results of this exercise are shown in Table 5. The first column indicates the estimated share of pretax profits in GDP--conventionally taken as a good estimate of the elasticity of output with respect to capital services. The second column shows the acceleration or deceleration of the capital-labor ratio from the 1960-73 period to the 1973-78 period for each of our seven major industrial countries.

Table 5.
 CONTRIBUTION OF SLOWDOWN IN CAPITAL-LABOR RATIO
 TO LABOR PRODUCTIVITY, 1960-73 TO 1973-78

	(1) Pretax Share of Profits in GDP	(2) Change In: Annual Growth of K/L (a)	(3) Contribution of K/L to Slowdown (b)	(4) Actual Slowdown (a,c)
Canada	.34	+0.5	+0.2	-2.1
France	.37	+1.0	+0.4	-1.7
Germany	.33	-0.4	-0.1	-1.0
Italy	.25	-2.4	-0.6	-4.3
Japan	.31	-3.4	-1.1	-5.6
U.K.	.29	-0.5	-0.1	-2.4
U.S.	.29	-0.6	-0.2	-1.9

Source: OECD unpublished data.

a) Annual growth rate 1973-78 less growth
 rate 1960-73, percent per annum

b) (3) = (1) x (2)

c) Output per employer, nonfarm business sectors

Multiplying columns (1) and (2) gives, in column (3), the growth-accounting estimate of the slowdown in labor productivity that should have come about because of the slowdown in the growth of the capital stock. This estimate is of the wrong sign or very small in five countries, and above the noise levels in Italy and Japan. But the major conclusion is clear: using the conventional analysis, in no country could the slowdown in investment and capital formation plausibly be a major part of the productivity slowdown. Indeed, in no country is the estimated contribution of capital more than one-fifth of the size of the productivity slowdown.

While crude, these calculations give the same qualitative answers as the more careful estimates for the United States. It is a puzzle, perhaps best left to the political scientists, how so small a factor can have become the major popular explanation for the slowdown.

3. A third possible explanation of the slowdown in productivity is slower output growth. The idea, which has found some support in work of the OECD, runs something like the following: A modern industrial economy is subject to significant economies of scale. If there is a slowdown in the growth of output, then there will also be a significant deterioration in the growth of productivity.

More formally, assume that the aggregate production function is of the form

$$\log(Y) = a + b t + c \log(K) + d \log(L)$$

where Y , K , and L are output, capital, and labor and t is time. Define $c + d$ as the scale coefficient (or the elasticity of output with respect to inputs). If the scale coefficient is significantly greater than 1, then a slowdown in the growth of output will slow conventionally measured labor or total factor productivity.

Figure 1 above shows qualitatively what the relationship looked like between the deceleration in output and the deceleration in productivity. The relationship is extremely striking, so much so that one would be tempted to conclude that the scale may be an important factor.

As noted above, a scale coefficient of 1.3 has been associated with output growth in the United States during business cycles; this might be closer to 1.1 in the long run--a figure chosen by Denison (1962) -- if the observed cyclical response is only part of a longer run adjustment mechanism.

Table 6 below shows the possible contribution of scale economies under alternative assumptions about the scale coefficient. The scale effect looks like a very promising explanation for at least a part of the slowdown. The fraction of the slowdown that can be explained ranges from one-tenth to one-third for a scale coefficient of 1.1 and from one-fourth to all of the slowdown for a scale coefficient of 1.3.

At the same time, it should be emphasized that there is a serious econometric identification problem from relying on the ex post

Table 6.

Contribution of Slower Output Growth to
Productivity Slowdown, 1960-73 to 1973-78.

	Actual Slowdown	Predicted Contribution with Scale Coefficient of (a)	
		1.1	1.3
Canada	-2.1	-0.3	-0.8
France	-1.7	-0.3	-0.9
Germany	-1.0	-0.3	-0.9
Italy	-4.3	-0.4	-1.2
Japan	-5.6	-0.8	-2.3
U.K.	-2.4	-0.3	-0.9
U.S.	-1.9	-0.2	-0.5

Source: OECD (1980), p. 10

(a) Equals (deceleration of output from 1960-73 to 1973-78 in nonfarm business sector) times (scale coefficient -1).

relationship between output and productivity. If there were constant returns to scale and productivity growth slowed for exogenous reasons, we would expect that policymakers would act to slow the growth of aggregate demand to prevent overheating of the economy. In this case, the ex post relationship would show a very strong correlation of output growth and productivity growth. Indeed, over a long period the slope of the relation shown in Figure 1 would be unity if all shocks were to potential output rather than to the utilization rate of potential output. While some analysts have been aware of this identification problem, I know of no studies which successfully separate out the two possible reasons for the correlation of output and productivity growth. Because of the possible contamination of the correlation, the results of Figure 1 and Table 6 must be viewed with some caution.

4. Inflation and macroeconomic policy. A good deal of hand-wringing about current economic conditions concerns the impact of inflation and the size or financing of the public sector, as well as the excessive (or is it insufficient?) growth of some monetary aggregate on productivity. These are particularly difficult issues to address, largely because the mechanisms by which these forces affect productivity are often unclearly defined.

There are two clear mechanisms by which inflation or macroeconomic policy might affect productivity-- through investment and through the efficiency with which existing resources are used. For the most part, the professional discussion stresses that inflation, high capital taxes, and high real interest rates led to a deteriora-

tion of economic performance by lowering investment. Thus a recent paper on the United States by Larry Summers (1981) estimates that an inflation increase of the order of the 1970s (he analyzes an 8 percent inflation shock) would lower the capital stock in the corporate sector by 12 percent after 10 years. While not a terribly robust conclusion, this indicates that there might be a strong impact of inflation or macroeconomic policy on productivity.

While one can quarrel with details of these studies, the evidence cited above on growth in the capital-labor ratio would appear to rule out this mechanism as an important one in the productivity slowdown to date, simply because there has not been a marked investment slowdown. Put differently, as the growth in the capital-labor ratio did not slow markedly, the investment mechanism cannot be the route by which inflation or macroeconomic policy caused the slowdown.

Of course, it might be argued that, but for these factors, the capital-labor ratio would have accelerated enormously; in which case the toll of inflation is a stable rather than rising capital-labor ratio. Whatever one might think about this last hypothesis, it is striking that, even after absorbing 1000 blows from all sides, there was so little decline in investment over the last decade.

The other possible route by which inflation or inappropriate macroeconomic policies could have affected productivity is through static inefficiency, such as through conventional resource misallocation. It is sometimes argued, for example, that relative price disequilibrium increases during inflationary periods.

While I know of no study that might shed light on this question, it appears to me to be a non-starter. Resource misallocation has been studied in depth in a number of areas for more than two decades; and the effects of pricing misallocations (such as those arising from international trade barriers or monopoly power) are usually in the order of a few tenths of a percent of total output. This is the "law of little triangles." If inflation were as important a source of static misallocation as monopoly, it might subtract a few hundredths of a productivity point per annum from productivity growth over the last decade; more than this amount is hard to derive from any analytical technique I know of.(11)

E. AN ANALYTICAL ANATOMY OF THE SLOWDOWN

Having reviewed briefly current knowledge about the sources of the productivity slowdown, I would next like to suggest an analytical apparatus for thinking about the slowdown. The apparatus relies upon the neoclassical growth model. Let us start by assuming that economic growth policies had been well-designed in the period before 1973. Figure 3 illustrates the growth equilibrium that might have been experienced in the 1960s. Given the consumption possibility curve-- $F(c_1, c_2)$ -- and the indifference curve-- $U(c_1, c_2)$ --the

(11) A study by Clark (1981) finds a significant historical association of inflation and the productivity slowdown. Using numbers from this paper, or from Fischer (1981), it appears that the standard deviation of annual inflation rates across commodities approximately doubled, from 3 to 6 percent, after 1973. If this is taken as a measure of the inflation-induced price misallocation (a rather wild leap of faith), and if price elasticities were uniformly -1, then the inflation-induced inefficiency would be in the order of 0.02 percentage points per annum over the period 1973 to 1979.

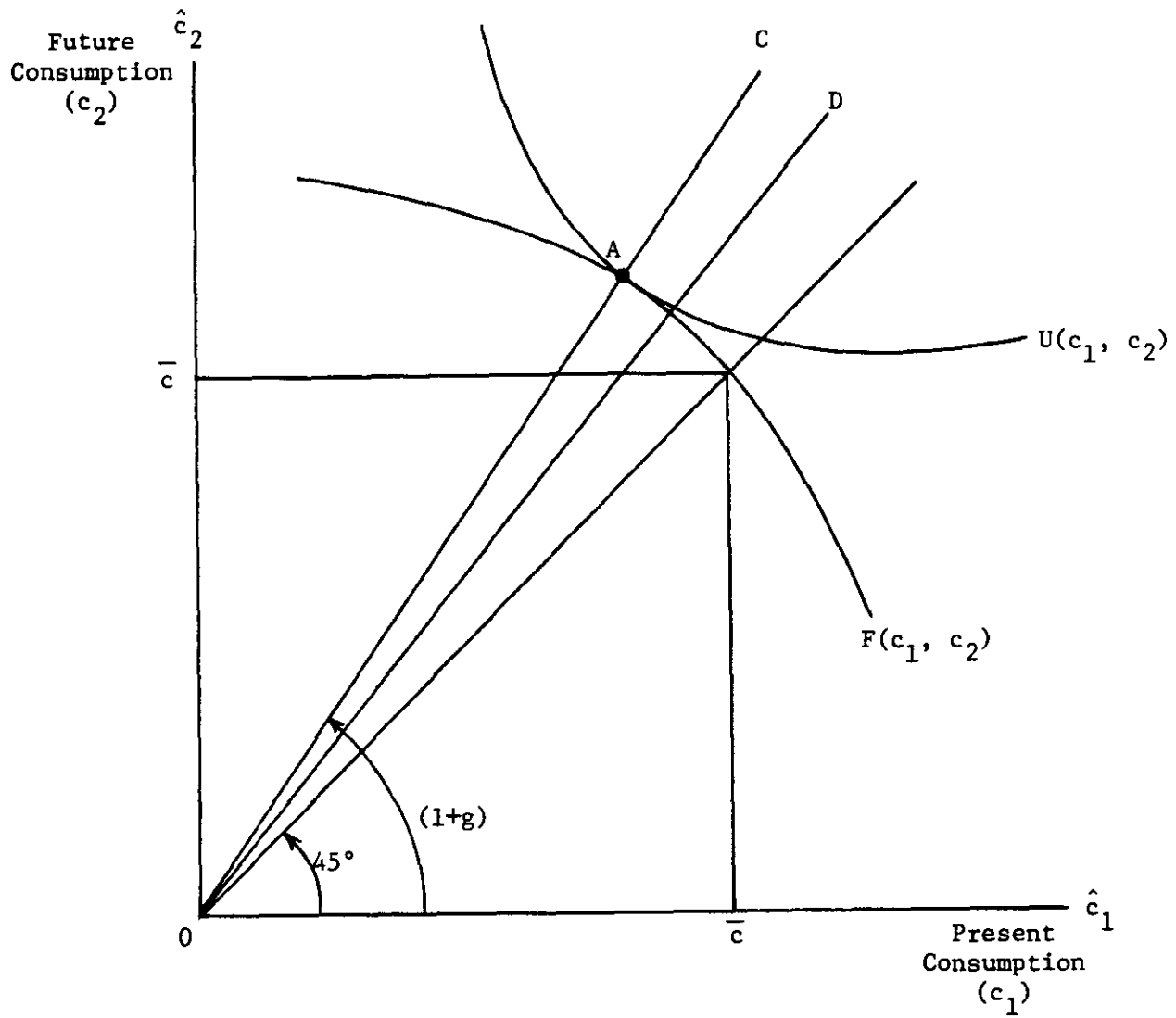


FIGURE 3. Illustration of outcome of choice of optimal growth path before productivity slowdown.

best outcome is with consumption (c_1, c_2). Savings in the first period is ($c^* - c_1$) and the economy grows at a rate g on ray from the origin OC .(12)

If we return to examine our economy a few years later-- after the productivity slowdown--what do we see? Unfortunately, we don't see the F or U functions in Figure 3. Rather, we simply observe that the economy is growing at a reduced rate along line OD rather than the earlier ray OC .

What are the causes of the reduced growth? In the various panels of Figure 4 we show four alternative explanations of the kink of forces that have been operating in recent years to slow productivity growth. We will first attempt to fit the different causes discussed in Part A into the analytical mold, then we will discuss the appropriate policy response.

Table 7 divides the "best guess" sources into the four categories. Needless to say, this division is not obvious, but the exact numbers are less important than the general outline.

a. The shift in tastes category shown in panel 4a would arise in two different cases. This observation rests on the view that the decade of the 1960s was a period devoted to enhancing economic growth, while the decade of the 1970s was a period of the retreat from affluence. I interpret the lack of further pro-growth policies during the 1970s and the attempt to internalize externalities as changes in tastes. In both cases, decisions were taken which were tilted toward consumption or away from conventionally measured out-

(12) The discussion of diagrams in the text is based on the standard optimal growth analysis. A formal description is given later.

Table 7.

Illustrative Division of Sources of
Productivity Slowdown Into Categories

<u>Category</u>	<u>Quantitative Significances</u> (percent of slowdown)
1. Shift in tastes	Capital (due to incentives). } 10% Internalize externalities.
2. Market failure	Capital (due to tax system). } 5%
3. Self-inflicted wounds	Regulation and cycle (due to poor policies). } 20%
4. Depletion	Energy. Investment (lower productivity of capital). } 65% Sectoral shifts. Cycle (due to slowdown). End of catch up. Slowdown of innovation.

put. A rough guess would be that one-tenth of the slowdown in the United States arose from this source.

b. The second category shown in Figure 4b is that market failure became worse. As noted above, there are few documented examples of how market failures have become worse during the last decade, although one example might be the interaction of inflation and the tax system which might produce lower investment or higher inefficiency. As noted above, this effect does not plausibly look large, so to be generous allow 5 percent of the total arises from market failures.

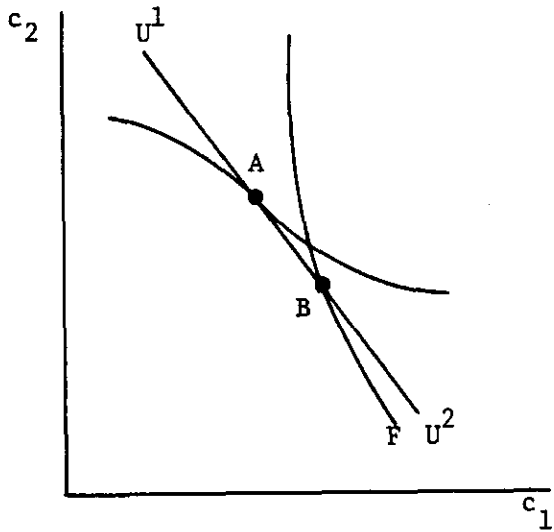
c. The third category is self-inflicted wounds. One clear case is poor cyclical management. Excessively expansionary policies before 1973, and poor choice of tools for fighting inflation since 1973, led to a distinctly slower growth rate and thereby slower productivity growth. A second example of poor management is excessively stringent or inefficient regulation. A rough guess is that 20 percent of the slowdown fits here.

d. The balance of the slowdown, totaling 65 percent, I will attribute to depletion. The evidence on the depletion hypothesis is qualitative and circumstantial but, as I will next indicate, persuasive.

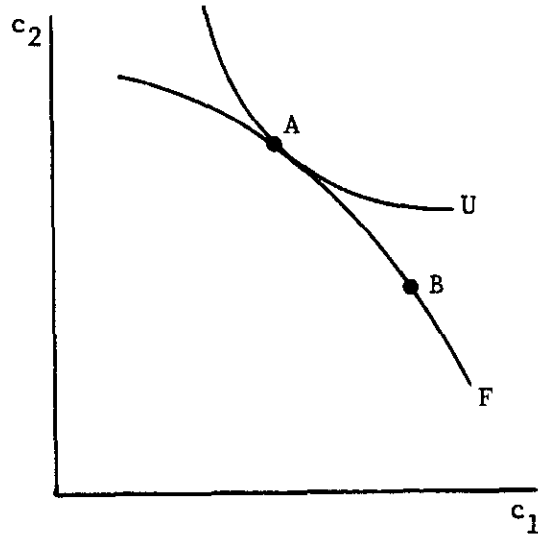
The depletion hypothesis

If we accept that the other three sources of slowdown explain only a third of the slowdown, this may suggest a different phenomenon at work. Is it not likely that we have temporarily exhausted many of the avenues that were leading to rapid technological change?

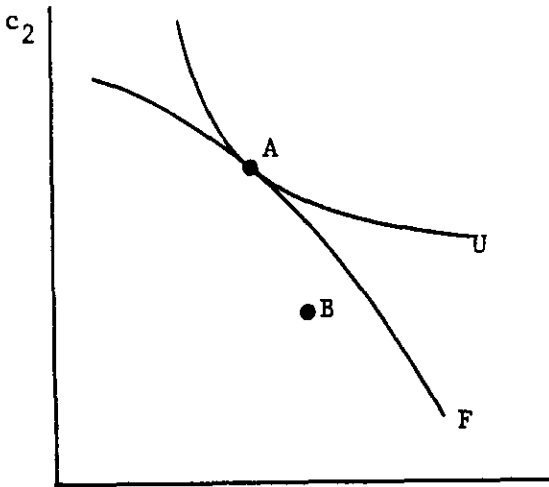
FIGURE 4. Illustration of four possible reasons for the productivity slowdown. In each panel, point A represents the consumption bundle before, and point B after, the productivity slowdown.



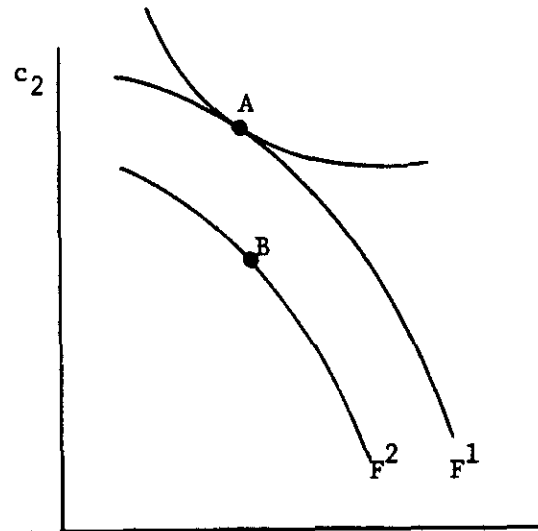
(a) Reduced growth because of change in tastes.



(b) Reduced growth because of undersaving



(c) Reduced growth because of self-inflicted wounds.



(d) Reduced growth because of depletion of resources and ideas.

There is no law of nature that technological advance should be at a steady rate. Perhaps we should not assume an anthropogenic origin for the productivity slowdown, but rather accept it as a a poor hand dealt by nature.

Our discussion of the sources of the productivity slowdown for the U. S. indicates that depletion is a quantitatively plausible explanation. The decline in productivity in extractive industries is of course a literal example of depletion. The decline in the return on capital and R & D (without a surge of either) seems to indicate depletion of investment opportunities. There is evidence that economies of scale in electrical generation and many process industries have been exhausted. We have also largely exhausted the productivity bonus due to sectoral shifts from agriculture to industry. It might also be appropriate to attribute to depletion the loss of the productivity bonus from economy-wide economies of scale arising in the wake of slower growth from depleted opportunities.

A final and more impressionistic notion is that the great inventions such as those we have witnessed in the past century (telephone, automobile, rayon, airplane, computer, transistor) are appearing less and less frequently. Table 8 illustrates the timing of a list of great inventions over the 20th century which does give some support for such a hypothesis.

Outside the U.S., the depletion arises in two forms in addition to those seen for the United States. For the early part of the postwar period, Europe and Japan were rebuilding from the war. In the later part, they were probably engaged in a catch-up with the

Table 8.

Distribution of Great Inventions
of the Twentieth Century

<u>Decade</u>	<u>Number of Inventions</u>
1900-09	5
1910-19	6
1920-29	5
1930-39	15
1940-49	15
1950-59	10
1960-69	4

Source: From Jewkes et al,
The Sources of Invention.
The dating of an invention is from first commercial
application or prototype.

most advanced technologies. Figure 5 shows the extent to which the catch-up phenomenon may have led to very rapid growth in early years, particularly in Japan and Germany. Both these special factors were becoming depleted by the 1970s.

Returning to an earlier question, it is plausible that depletion might be the common cause of the slowdown in the several countries? Some of the sources of depletion might have plausibly occurred simultaneously in a number of countries in 1973. Thus the depletion of energy resources, the depletion of investment opportunities in the tradable goods sector, the slowdown in world trade, and catch up to the most advanced techniques might plausibly have occurred everywhere in the late 1960s or early 1970s. For some of the others, the degree of coincidence is uncomfortably high. In particular, why should depletion of innovation, exhaustion of scale economies, and playing out of sectoral shift from agriculture to manufacture have occurred at the same time? The implausibility of coincident timing is, in my mind, the major reason to question the quantitative dominance of the depletion hypothesis.

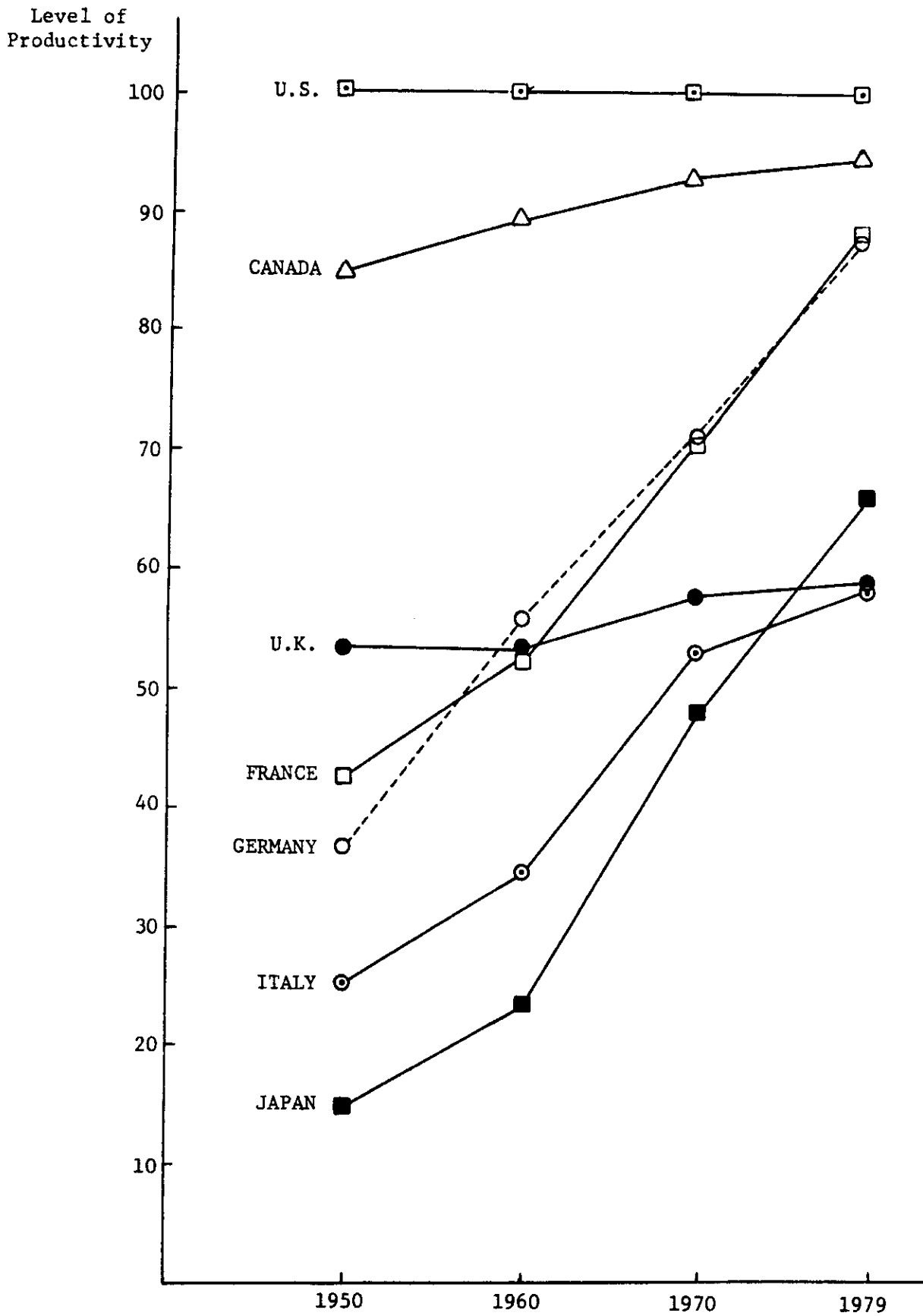


FIGURE 5. International productivity comparisons. U.S. = 100.

Source: U.S. Bureau of Labor Statistics.

C. POLICY RESPONSE TO SLOWER PRODUCTIVITY GROWTH

We next turn to a detailed discussion of the appropriate policy reactions to each of the different sources of the productivity slowdown. We first discuss how we might respond to poorer growth performance under each of the four categories in Figure 3. We then turn to a more systematic discussion of policy response in an optimal growth model.

a. In Figure 4a we consider the possibility that a change in tastes has led to a reduction in the desired growth rate. Such a change would reflect a transition to a lower steady state growth path as the saving rate is reduced. In our formal model below, such an outcome might arise because of greater impatience (higher r) or a lower tolerance for inequality across generations (higher b). The revulsion against the abuses of an industrial society, the rise of "no growth" philosophies, and social regulation are less easily formalized but obviously important forces, and the impact of regulation attests to their importance; we guessed that 10 percent of the slowdown can be attributed to this source.

If these changes of taste occurred in a way that reflects true preferences (whatever that might mean), and were efficiently brought about, we would presumably accept the outcome and not wish to undo it. That is, if we wish to grow slower because people are persuaded that a no-or-slow-growth society is preferable, then it would hardly seem sensible to reverse these policies because they have succeeded.

b. A case with the same observable outcome as case (a) is that, through mistaken policies or worse market failures, the economy has been undersaving and underinvesting. We guessed that 5 percent of the slowdown arose here. One mechanism by which a market failure could occur is inflation. As a result of the acceleration of inflation, the fraction of tax to replacement cost depreciation has fallen from 100 percent in 1965 to 90 percent in 1979. Similarly, in inflationary periods the taxation of nominal interest payments as ordinary income raises considerably the tax rate on property income. Both of these could lead the economy to save and invest less. If we are convinced that we have fallen into the undersaving trap, the policy response is clear: we must correct the market failures (the tax code or our inflationary ways), tighten our belts, and save and invest more.

Some will find it highly surprising that undersaving and underinvesting through (a) or (b) are given such little weight here. In fact, there is little empirical support for these views. We noted above that investment appears to have slowed little in most industrial countries.

In addition, it is clear that both theories (a) and (b) have a fatal flaw as explanations of recent behavior. They both have an unambiguous prediction that the marginal product of capital, and therefore the pretax rate of return on investment, should have risen since the days of high productivity growth. The clear evidence is that the rate of profit has fallen. Thus for 1955-69 the pretax rate of profit on corporate capital was 12.9 percent, while for the

1970s it fell to 9.4 percent. Similar data are given in the McCracken report for other industrial countries, where the evidence is even more compelling. More generally, I regard it as one of the major puzzles of economic psychology how those who argue that the United States is now undersaving relative to earlier periods ignore the fact that the historical behavior of the profit rate does not corroborate their theories.

c. The third view of the productivity crisis, illustrated in Figure 4c, is that countries have with increasing frequency taken to shooting themselves in the foot. Increasingly stringent social regulation is the most prominent example of policies which inhibit growth. There are, in addition, counterproductive policies such as payroll taxes, minimum wages, self-imposed trade embargoes, and trade restrictions. Empirically, we found some evidence that self-inflicted wounds, or obstacles, have led to a minor portion of the productivity slowdown--perhaps 20 percent of the slowdown arises here.

The policy response to self-inflicted wounds is obvious--ban economic handguns--but it may not be politically popular. All stripes of politician agree that we should pursue the abstraction of more effective regulation. Few argue that we should reduce safety standards for nuclear power or abolish the minimum wage. And protectionism appears to be the perennial brothel of politicians who espouse the virtues of undying fidelity to the free market.

d. The final category into which we might put the productivity slowdown, shown in Figure 4d, is that of depletion. Is it not

possible that we are riding down the backside of a long-term decline in productivity growth, a Kontradieff cycle? In this case the consumption possibility curve in Figure 3d has shifted inward; for a given level of first period consumption, second period consumption (and growth) is reduced. We guessed that 65 percent of the slowdown was attributable to depletion.

As we indicated in the last section, of all the possible sources of the productivity slowdown, depletion is the one for which a policy response is most difficult to prescribe. Should we jog less or more as we get older? If oil is expensive to find, should we drill more or go to the beach. In Figure 4d, we see generally that the new optimal consumption choice may show a higher or lower growth rate depending on the shape of the utility function and on the way that the consumption possibility curve shifts.

The next section turns to the question of whether a more careful specification of optimal policy allows us to say whether an economy should save more or less after a slowdown in the exogenous rate of technological change.

Policy Response in an Optimal Growth Model

In some special cases we can make limited statements as to the optimal policy. The productivity slowdown is here best seen as a decline in the rate of labor-augmenting technological progress.

In order to make the verbal discussion above more rigorous, we can turn to optimal growth theory of the following kind.

Let $c(t)$ be consumption per worker at time t and $L(t)$ the size of the work force. We assume that the labor force is a fixed proportion of the population; therefore, $c(t)$ can also be regarded as an index of per capita consumption. The labor force L is growing exponentially at rate n . Labor-augmenting technical progress is occurring at rate h ; so $L(t)\exp(ht)$ is the effective labor force, which is growing at rate $g = n + h$. Output per worker, x , is $\exp(ht)f(k)$, where k is the ratio of capital stock to effective labor force $K/L\exp(ht)$. Capital is assumed to last forever.

Finally, let $i(t) = f'[k(t)]$ be the next instantaneous

t

return on capital and $q(t) = \exp \left[\int_0^t i(v)dv \right]$ be the

0

t - period rate of return. Then a unit reduction of per capita consumption at time 0 will yield $\{q(t) \exp(-nt)\}$ units per capita consumption at time t .

The other half of the story relates to the social valuation of increments of future consumption yielded by current saving. Suppose that society's intertemporal preferences can be described by an additive social welfare function

∞

$\int_0^{\infty} u[c(t)] \exp(-rt)dt$ where $u(c)$ is the one-period

0

utility of consumption, r is the constant pure rate of time preference at which utility is discounted, and the elasticity of margi-

nal utility with respect to consumption, assumed constant, is $u''c/u' = -b$.

An optimal consumption path equates the marginal cost and marginal value of saving. In general, this requires that $i(t) = n + r + bc'(t)/c(t)$. In steady state, this reduces to $i = n + r + bh$.

We can ask two kinds of questions of our simple economy: First, what is the long run impact effect of a productivity slowdown (decline in h) on the optimal savings rate, on the capital-labor ratio, and on the interest rate. Second, what happens to the investment rate (or savings rate) in the short run after a slowdown of productivity growth has occurred?

1. The long run

One case that is easily examined is where the capital-output ratio is technologically fixed. In this special case, the savings rate would be given by $s = v(n + h)$; thus the optimal savings rate clearly declines linearly with a decline in the rate of labor-augmenting technological change. Given the restrictiveness of the assumption of a fixed capital-output ratio, this case is of little practical interest.

A more interesting case arises when production can be described either for a Cobb-Douglas production function or when there is a "small" change in the rate of technological change.

In this case, write the production function as $\log(y) = a \log(k) - ht$, where y is output per unit of efficiency worker = $x \exp(-ht)$. Also, a is the elasticity of output with respect to capital--a constant in the Cobb-Douglas case, and taken as constant in

the "small" change case. Our condition for an optimal steady state path is:

$$(1) \quad i = r + n + bh = a y / k.$$

Solving for k we obtain:

$$k = \left[\frac{a}{r + n + bh} \right]^{1/(1-a)}$$

It is easily verified that the optimal capital-labor ratio rises as the technological change declines.

The second relation concerns the optimal savings rate. In the model, it can be shown that the optimal long-run savings rate is given by:

$$s = (n + h) k^{1-a}$$

so we have

$$(2) \quad s = (n + h) \left[\frac{a}{r + n + bh} \right]$$

With a little work it can be shown that ds/dh has the sign of $r + n(1-b)$.

For "reasonable" values of parameters, that is those producing growth and interest rates like those prevailing in the OECD countries today, it seems to me a toss-up as to the effect of a productivity slowdown on savings in the long run. Assume the rate of profit on capital is about 8 percent, the growth of population 2 percent, and the growth of productivity before the slowdown was 2 percent. If we were in steady state optimal growth path, this implies from our steady state equation in (1) that:

$$(3) \quad r = .06 - .02b$$

We can evaluate the effect on the savings rate in (3) by taking alternative values of r and b that are consistent with (3). If we go to one extreme and assume no time preference, so that $r = 0$, then $b = .03$, ds/dh is negative, and savings should rise with a productivity slowdown. If we go to the other extreme and assume no aversion to inequality ($b = 0$), then $r = .06$, ds/dh is positive, and savings should fall with a fall in productivity.

Given that interpreting reality in light of the optimal growth model is already reflects a suspension of disbelief of a magnitude that would fit into the Guinness Book of Records, perhaps we should simply say that the effect of a productivity slowdown on the savings rate in the long run is ambiguous.

2. The short run

The effect in the short run can be seen by examining the short-run consumption growth trajectory in the optimal path. Let $m(t)$ = the growth of per capita consumption. Then along an optimal path, we have:

$$i(t) = r + n + b m(t)$$

where $i(t)$ is the instantaneous rate of return on capital. Solving for the optimal rate of growth of consumption,

$$m(t) = \frac{i(t) - n - r}{b}$$

Note that none of the parameters in the equation for the consumption trajectory change in the very short run: n , r , and b are pa-

rameters while $i(t)$ is the marginal productivity of capital, which is unaffected by the productivity slowdown in the very short run.

Thus we find that along an optimal path, there is no change in the very short run in the growth rate of consumption although there may be a jump in the level. We know, however, something about transition paths from work by Mirrlees in 1967. He showed that in the Cobb-Douglas case, the savings rate would be falling over time if $(1 - a)h > an$. As h and n are generally of the same order of magnitude, it seems very likely that the savings rate in an optimal path would therefore fall over time.

Thus, in the Cobb-Douglas case, if the long-run savings rate rises or stays the same after a productivity slowdown, we are pretty sure that the nation will want to save somewhat more in the very short run. If, on the other hand, the long run savings rate falls, short run behavior is unclear.

The discussion can be put intuitively as follows for a special case: Assume that the production function is of a fixed-proportions variety. Then it is easily seen that the optimal savings rate will decline after a productivity slowdown. The reason why the optimal savings rate is lower after a productivity slowdown is straightforward: the amount of capital needed to equip a growing labor force declines.

As an example, assume that the labor force is constant, that labor force quality and output growth both grow at 4 percent annually, that the capital-output ratio is fixed at 2, and that 6 percent of capital depreciates annually. Then 20 percent of gross output

must be set aside for investment--12 percent for replacement plus 8 percent for growth.

If the rate of labor quality improvement and output growth decline to 2 percent, then the required savings rate is 12 plus 4 or 16 percent. Thus because output is growing more slowly, the need for capital broadening is reduced.

To sum up this excursion into the implications of taking a consistent optimizing framework about savings-investment decisions, where that framework is the standard neoclassical optimal growth model:

Depletion of technical opportunities can be described as a slowdown in the exogenous rate of labor-augmenting technical change. If an economy has followed a policy of allocating its resources over time in a way described by the neoclassical optimal growth model, then the impact of such a slowdown in productivity growth on savings behavior is ambiguous. Depending on parameters of the production function and of tastes, the fraction of national income devoted to investment may either rise or fall.

In sum, there is no justification from growth theory for the view that we should tighten our belts and save more because productivity growth has slowed.

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