Policy Responses to the Productivity Slowdown

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Much has been written by economists about the sources of the productivity slowdown; and self-serving policy recommendations by interest groups abound. Strangely, the two are seldom connected. 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 U.S. productivity slowdown are numerous. How we should respond depends on what has happened. A less fanciful example of the dilemma can be seen in the area of drilling for oil. Figure 1 shows the finding rate for oil over the last 15 years. As can be seen, there was a sharp break in the trend in 1973: whereas finding rates had been falling at about 1 percent per year up to 1974, from 1974 to 1978 they fell at 12 percent per year.

What was the source of the productivity break in oil drilling in 1974? 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 in 1973 to control oil prices. In the depletion category we might guess that the dramatic upturn in drilling rates 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 oil drilling 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 simply been dealt a poor hand by nature (depletion of resources or new ideas, low marginal productivity of capital), then the appropriate response is much 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

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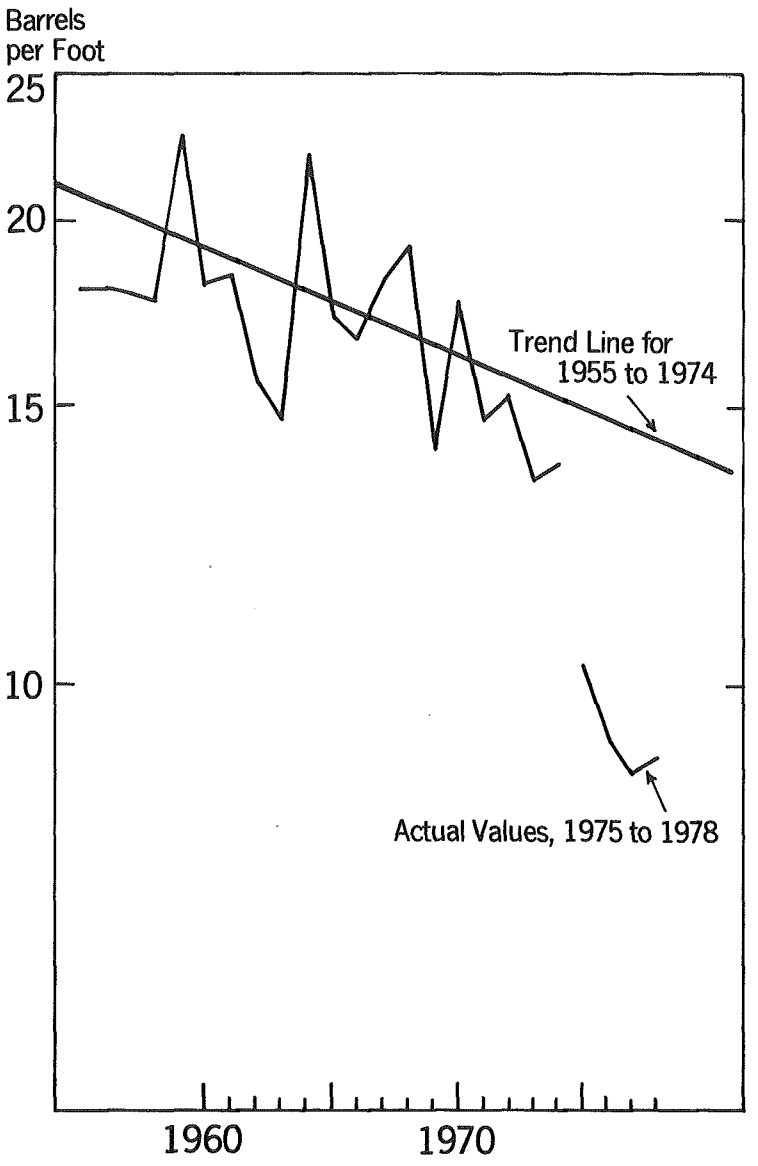
Figure 1
Productivity in Oil Drilling, 1955-78
(Crude oil reserves added per successful oil foot drilled)



Source: U.S. Department of Energy, Historical Review of Domestic Oil and Gas Exploratory Activity, October 1979, DOE/EIA-1096.

Table 1
Measures of Productivity Performance, before and after 1973

	[Annual average growth rate, percent] 1948–73	1973–79
Output per Hour of all persons:		
Total Economy	2.3	0.2
Private Business	2.9	0.6
Nonfarm Private Business	2.4	0.5

SOURCE: *Economic Report of the President, 1980.* Figure for total economy is real GNP divided by total employment.

activities? There is no clear answer. Some old joggers try harder while others fade away.

With these introductory notions, I now turn to a discussion of the productivity puzzle and policy reactions. The next section provides my personal synthesis of existing studies. The following sections then review policy responses.

A. Sources of the Productivity Slowdown

The purpose of the present section is to review the recent discussion of the productivity slowdown. I will use the inaccurate "productivity slowdown" as shorthand for "a slowdown in the growth rate of labor productivity." 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 obstacles theory given above?

1. *Has there really been a productivity slowdown?*

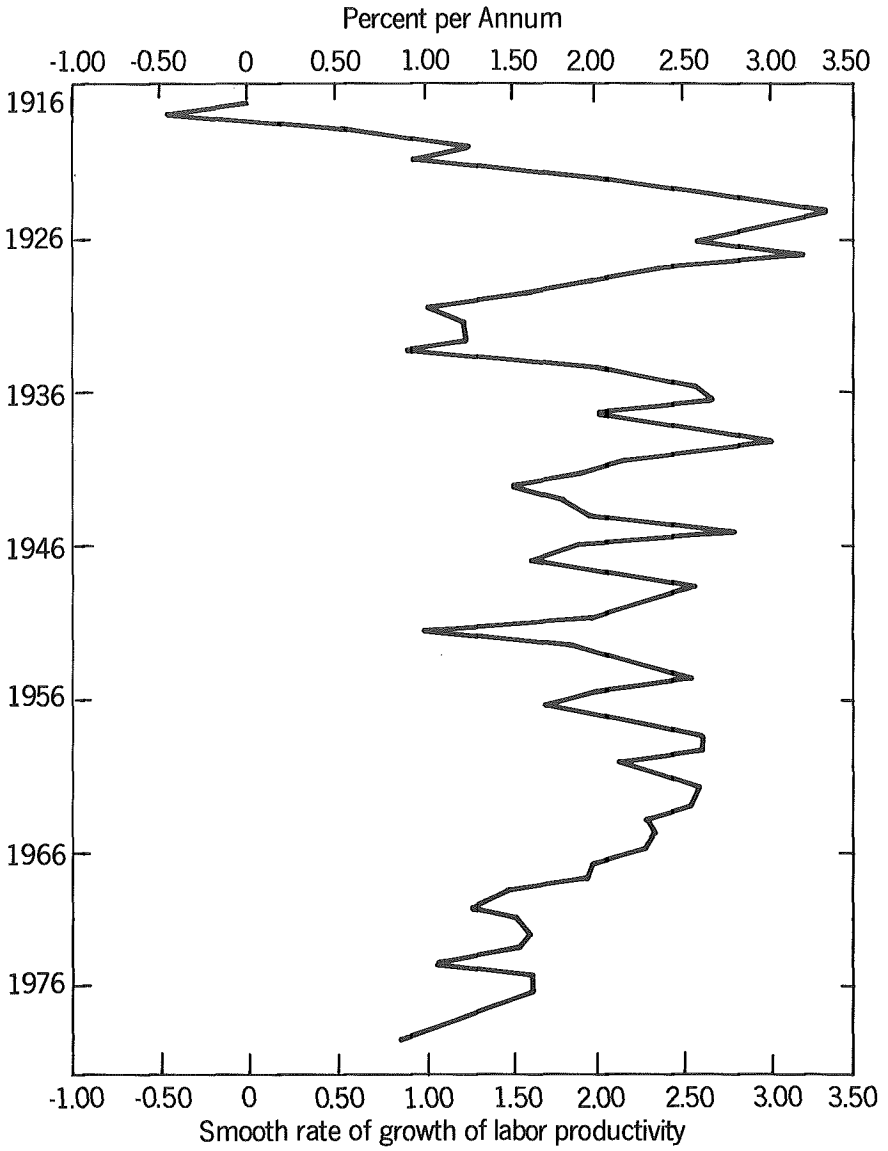
It is by now generally accepted that the productivity growth rate in the United States has significantly slowed down over the course of the 1970s. There is no consensus about the exact timing of the slowdown; productivity growth has clearly slowed since the early 1960s, but whether the decisive year 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. As a rough rule of thumb, the growth in the private business economy has fallen from around 3 percent per annum to about 0.5 percent per annum after 1973.

It should be noted that the productivity decline is also extremely widespread. Of the 12 major industry groups, only communications and the fi-

Figure 2

Estimated Long-Term Growth of Productivity



Series is output per worker-hour in the private nonfarm business economy. Cyclical influence has been removed as described in footnote 1. For each year the rate is the six-year average ending in year shown on left.

nance, insurance, and real estate group have not suffered a slowdown in the post-1973 period. The productivity slowdown has also been felt in all major industrial countries. Although it is not clear why this fact should make us more convinced that the U.S. slowdown is real, the fact that the slowdown is universal should point us toward widely felt explanations.

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 ark—although after 30 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 long 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 U.S. business sector running over the period 1909 to 1979. Using standard techniques I removed the cyclical influence on productivity.[1] I then asked a number of questions about the past behavior of the cyclically corrected series.

First, we can simply inspect the time series on productivity growth. The most revealing series, shown in Figure 2, is the long time series on smoothed, cyclically corrected productivity growth. For this series, I chose a six-year moving trend (corresponding to the six lean years since 1973). The results are quite striking. If we ignore the wiggles, the rate of productivity growth from World War I to the middle 1960s was more or less constant. Starting about 1966, however, a slow but steady downward creep has occurred from an average of 2 to 2½ percent annually to a level of slightly under 1 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 to 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 the structure changed after 1973. To do this, we simply take the regression described in footnote 1 below 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), the decline in productivity is statistically significant (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

[1] The cyclical influence was removed as follows: A regression of productivity change on output growth and lagged output growth was run; the coefficients 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
Changes in the Rate of Growth of Labor Productivity: Pre-1965 to Post-1972

	J. Kendrick	Norsworthy, Harper, Kunze	Norsworthy, Harper, Kunze	E. Denison	Z. Griliches	P. Clark	P. Clark	L. Thurow	Miscellaneous
Sector	Private Business	Private Business	Private Nonfarm Business	Total Economy	Manufacturing	Private Nonfarm Business	Private Nonfarm, Nonresidential Business	Private Nonfarm Business	Private Business
Output Measure	Gross Dom. Inc.	Gross Dom. Inc.	Gross Dom. Inc.	Net Nat'l. Inc.	Gross Output	Gross Dom. Inc.	Gross Dom. Inc.	Gross Dom. Inc.	
Periods Studied	1948–66 & 1972–78	1948–65 & 1973–78	1948–65 & 1973–78	1953–64 & 1972–76	1959–68 & 1969–77	1948–65 & 1973–76	1948–65 & 1973–78	1948–72 & 1972–78	
Total Decline	−2.40	−2.12	−1.68	−2.64			−1.83		
Cyclical	−0.30			−0.05				−0.40	
Trend						−1.67			
Capital	−0.40	−0.74†	−0.57†	−0.17		−0.4 to† −0.97	−0.54†		
Labor	+0.10	−0.28	−0.18	−0.14		+0.04			
Energy		−0.18 (manufacturing)	−0.18 (manufacturing)	−0.10					−0.6 (Jorgenson–Hudson) −1.3 (Rasche–Tatom) −0.2 (G. Perry)
Regulation	−0.30	−0.09	−0.08	−0.27				−0.20*	
Research	−0.60			−0.10	−0.10 to −0.40				
Sectoral Shifts	−0.50			−0.27				−0.60**	−0.10 (CEA)
Other Factors	−0.30	−0.83	−0.67	−1.54		−0.67 to −1.28	−1.29		

Table 3
"Best Guess" Sources of Productivity Decline*

Total Decline	2.5 percentage points
Cyclical (slower growth in output)	0.3
Trend	2.2
Sources:	
Capital	0.3
Labor	0.1
Energy	0.2
Regulation	0.2
Research & Development	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 1973–79. Output is gross product originating in the private business sector. Note that a positive number indicates a slowdown.

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. On the basis of the postwar period, we would expect to draw a hand as bad as that of the last six years once every four decades. Over the entire sample period, we would expect as bad a hand about once a decade.

2. Why has productivity slowed?

From now on I will assume that productivity has slowed and turn to the reasons. By now a gaggle of studies is available on the sources of the slowdown, but I will restrict my attention to those that deal with broad aggregates rather than with individual industries. With the assistance of Robert Lurie of Yale University, I have compiled in Table 2 the key results of several of the recent studies.

In the various studies, seven important factors have been identified as possible sources of the productivity slowdown. For the most part, the technique used to estimate the effect of the specific factor on productivity growth is known as "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.

We will not attempt to summarize the studies in any detail at this point, but make general comments about the overall findings. In addition, for the private business economy, we make in Table 3 a "best guess" as to the magnitude and the source of the productivity slowdown.

It is generally agreed that the slower rate of growth of the capital stock has contributed significantly to the productivity slowdown. The severe reces-

sion after 1973, as well as policies which were less pro-investment than in the earlier periods, led to a significantly slower growth in the utilized capital stock. In addition, a point omitted in most studies, the profit rate on capital (and presumably the marginal productivity of capital) has declined in recent years. This would imply that at a given rate of growth of capital the contribution to output would be smaller. There is a serious problem in most of the estimates in Table 1 of the contribution of the capital stock (see Berndt's paper in this volume). 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. The best guess as to the contribution of the slower growth of the capital stock to the slowdown is 0.3 percent per annum; changes in utilization since 1973 should hardly be attributed to cost of capital or similar variables.

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; consequently, the best guess is that labor quality subtracted approximately 0.1 percent annually from productivity growth.

The contribution of energy to the productivity slowdown is extremely controversial, and is discussed elsewhere in this conference. The estimates generally converge on numbers in the range of 0.1 to 0.2 percent per annum, except for models which have a rapid adjustment of the capital stock to change relative prices. Given the implausibility of the latter assumption, we will use 0.2 percent per annum as the best guess for the contribution of changed energy prices to the productivity slowdown.

The influence of regulation is perhaps the most difficult effect to measure. The direct effects — inputs diverted 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 or innovation, entrepreneurship, or choice of techniques — do not appear in the estimates. As I suspect the latter are quite significant, I use the high end of the range in estimating the effects of regulation on productivity.

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.

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 find some modest effect of cyclical conditions — ranging up to 0.3 percent for the period 1973 to 1978. It should also be noted that the utilization correction discussed under capital above is really a cyclical correction rather

Table 4
Sources of Productivity Slowdown and Appropriate Policy Responses

Category	Quantitative Significances (percent of slowdown		Policy response
1. Shift in tastes	Capital (due to incentives). Internalize externalities	10%	no response
2. Market failure	Capital (due to tax system).	5%	correct market failure
3. Self-inflicted wounds	Regulation and cycle (due to poor policies).	20%	Improve regulatory and anti-inflation policies
4. Depletion	Energy. R&D. Investment (lower productivity of capital). Sectoral shifts. Cycle (due to slowdown) Residual.	65%	Ambiguous. Probably save smaller fraction of output.

than a capital contribution. In a statistical test performed for this paper (and described in footnote 1) I found that the slower economic growth for the private business sector contributed about 0.3 percent to the slowdown after 1973. I will use 0.3 percent as a reasonable best guess.

Table 3 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.

B. Policy Responses: General Principles

Having reviewed briefly current knowledge about the sources of the productivity slowdown, I turn to the question of how we should respond. I first discuss general principles and then turn to specific suggestions.

To begin with, can the literature on economic growth say anything about how policy should respond to the productivity slowdown? 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 utility function — $U(c_1, c_2)$—the best outcome is with consumption $(\hat{c}_1, \hat{c}_2)$. Savings in the first period is $(\bar{c} - \hat{c}_1)$ and the economy grows at

Figure 3

Outcome of Choice of Optimal Growth Path Before Productivity Slowdown

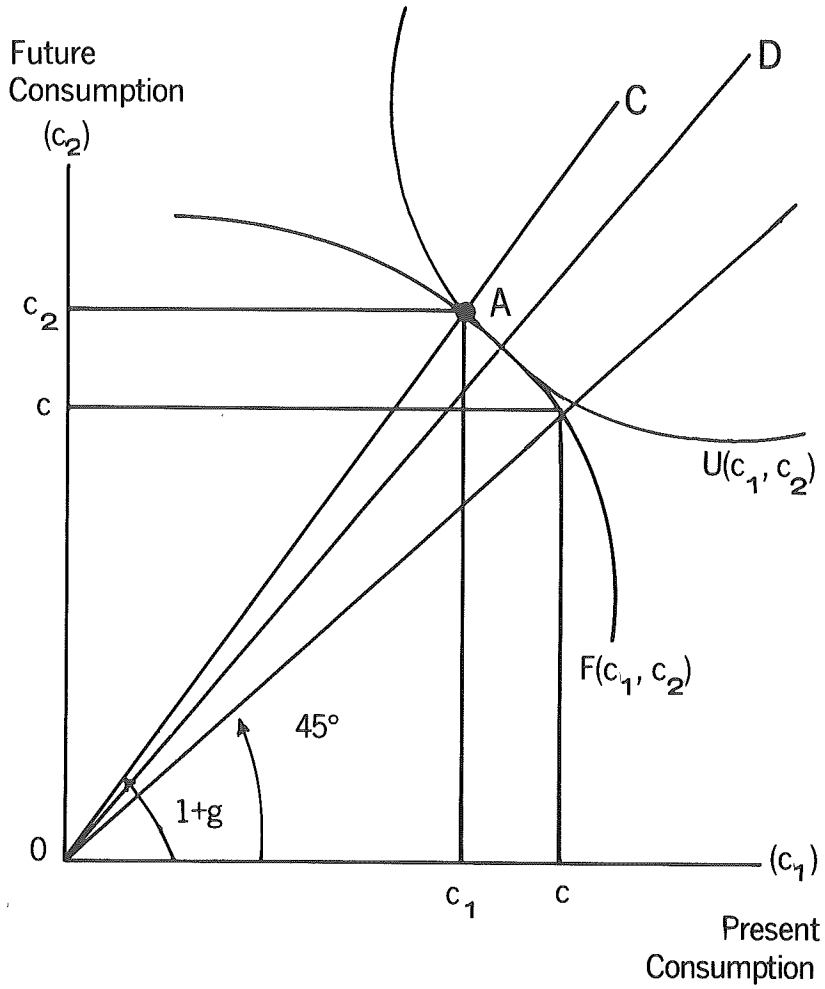
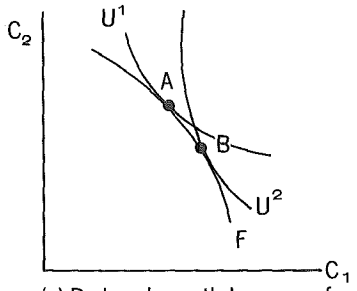
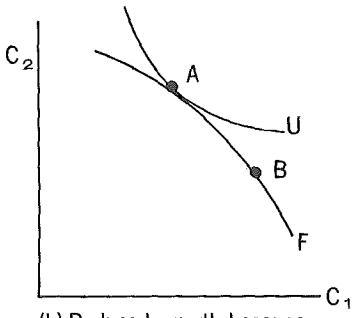


Figure 4

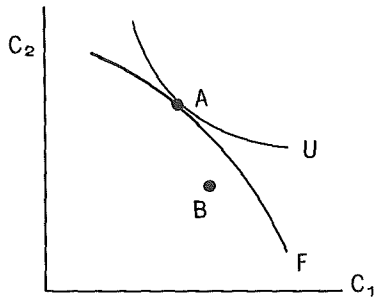
Illustration of four possible reasons for the productivity slowdown. In each panel, point A represents the consumption bundle before, and point B after, the productivity slowdown.



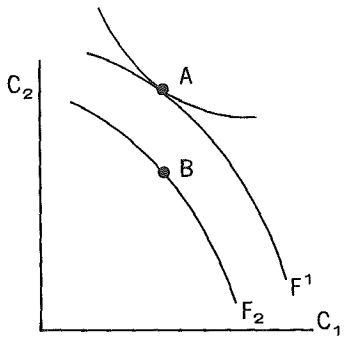
(a) Reduced growth because of change in tastes.



(b) Reduced growth because of undersaving.



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



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

rate g on ray from the origin OC.[2]

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 the important possibilities. We will first attempt to fit the different causes of part A into the analytical mold, then we will discuss the appropriate policy response.

Table 4 divides the "best guess" sources into the four categories, and notes the appropriate policy response. 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 would arise in two cases. 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 output. A rough guess would be that one-tenth of the slowdown arises from this source.

b. The second category is market failure. As noted below, there are few documented examples outside of the role of inflation in the tax system, and this is ambiguous. I would guess 5 percent as a total.

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, can be attributed to depletion. The evidence on the depletion hypothesis is quantitative and circumstantial but, in my view, persuasive. The review of sources of productivity growth above seems unable to find a substantial number of causes of type (a), (b), and (c), so we are probably left with depletion as a residual. 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 processing industries have been exhausted. We have also largely exhausted the productivity bonus due to sectoral shifts from agriculture to industry. It would also be appropriate to attribute to depletion the cyclical (or economies of scale) effects that are due to these items. Finally, and vaguest of all, I have the impression that great inventions such as those we have witnessed in the past century (telephone, automobile, rayon, airplane, computer, ballpoint pen) are

[2] The discussion of diagrams in the text is based on the standard optimal growth analysis. A thumbnail description of the derivation of the informal presentation is given in the Appendix.

appearing less and less frequently.

We next turn to a detailed discussion of the appropriate policy reactions to each of the different sources of the productivity slowdown.

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 of the Appendix, such an outcome might arise because of greater impatience (higher ρ) 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 it did occur through a legitimate channel, presumably we would 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 market failures, the economy has been undersaving and underinvesting. We guessed that 5 percent arises 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. It is useful to note 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 undersaving ignore the fact that the profit rate does not corroborate their theories.

c. The third view of the productivity crisis, illustrated in Figure 4c, is that the United States has with increasing frequency taken to shooting itself in the foot. Increasingly stringent social regulation is the most prominent example

of policies which inhibit growth, although there appears to be, as well, increasing sensitivity to the counterproductive facets of policies such as payroll taxes, minimum wages, self-imposed 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. While all agree that we should pursue the abstraction of more effective regulation, few argue for venting gases from Three Mile Island, or for killing the sacred cows of microeconomic policy (Davis-Bacon, minimum wages, etc.).

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 4d 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.

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 fewer or more holes? In Figure 4d, we see more generally that the new optimal consumption choice may have a higher or lower growth rate depending on the shape of the utility function and on the way that the consumption possibility curve shifts.

In some special cases we can make limited statements as to the optimal policy. Take as an example the case formally analyzed in the Appendix — the standard optimal growth model. The productivity slowdown is here best seen as a decline in the rate of labor-augmenting technological progress. In such a circumstance an optimal response is to reduce the equilibrium rate of return on investment (the reduction is proportional to the extent to which higher consumption is less valuable, b). But for a Cobb-Douglas (or substitution inelastic) technology *the eventual optimal savings rate will be below that which held before the 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 output must be set aside for investment — 12 percent for replacement plus 8 percent for growth. If the rate of 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. If the slowdown is a result of depletion, we can make a strong argument for investing less rather than more.

C. Specific Policy Responses

Having spent most of my time circling the issue, it is time to attack the question of specific policy responses to the productivity slowdown. It is useful to group our approaches into "demand side" and "supply side" approaches. The first two policy tasks (inflation and demand management) refer to the demand side, while the next three (investment, regulation, and energy policy) concern the supply side.

1. *Anti-inflation policy*

The first issue on the demand side concerns the role of anti-inflation policies in productivity policies. We must here separate out inflation per se, which we discuss here, from the indirect effects of inflation on demand management or supply side, which we turn to later. Little serious research can be drawn on to indicate the extent to which inflation is the proximate or ultimate cause of our problem. One clear mechanism, discussed in the Kopcke paper, is that inflation may raise the burden of taxation on capital because depreciation allowances do not rise as fast as economic depreciation. He argues that much of the decline in investment (and therefore of productivity) "can be attributed to rising inflation since the late 1960s."

I find the Kopcke argument unconvincing on two grounds. First, he nowhere actually shows what, in his model, inflation has done to the cost of capital and to productivity. Much more important, however, is that he omits from his argument the fact that inflation is a double-edged sword. It not only cuts the fraction of true depreciation that is deductible, but it also raises interest deductions because of the effect of inflation on nominal interest rates.[3] Examine the ratio of the sum of positive incentive due to interest deductibility and negative incentive due to illiberal depreciation allowance to true profits. This ratio has risen from 0 in 1955 to 12 percent in 1965 to 21 percent in 1979. Hardly a major disincentive. In fact, the recent outpouring of complaints of unfair depreciation rules shows a scandalous lack of attention to the fine print. A perusal of company reports indicates most companies are gaining more from deductibility of interest than they are losing from illiberal depreciation.

A second area in which inflation can lead to slower productivity growth is through resource misallocation. Thus, in regulated utilities the fact that control systems are designed for noninflationary periods means that, recently, marginal costs are well above average historical costs. Similar misallocation arises because of tax distortions, such as the fact that high debt-equity industries (electric utilities) have lower effective tax rates. There are other, but vaguer, misallocations concerning inflation's effects on risk and uncertainty. And, of course, there is the classical cost of inflation — shoe leather.

[3] A more rigorous treatment shows that inflation actually raises tax deductions for high debt equity ratios, long lifetimes, and high inflation rates. For example, with inflation of 10 percent, a constant pretax real interest rate of 5 percent, a lifetime of 10 years, and a 1:2 debt-equity ratio, an increase in inflation decreases the cost of capital (increases the post-tax return on investment).

I am unaware of any studies which would impute large annual costs to these misallocations due to inflation. Indeed, the theorem of little triangles suggests that inflation losses — like monopoly or tariff losses — are unlikely to be more than a few tenths of a percent of output.

On the whole, then, it is hard to see a convincing link from the recent inflation to productivity. If this is the case, this victory over inflation by itself will contribute little to improving our productivity performance.[4]

2. *Demand management policies*

A second area on the demand side which might have a significant effect on productivity is demand management. Here a number of facets of demand management might affect productivity. Four that come to mind are growth, level, and variance of the pressure of demand, as well as composition and possible bias in demand management policies.

a. The overall growth of aggregate demand clearly has a significant impact on productivity growth. Growth in the 1973–79 period was 1.1 percent slower than in 1948–65, and we guessed this might be responsible for 0.3 percentage points of the slowdown. Most of the slowdown in recent years is, however, lower potential output due to lower productivity, so that the remedy for slower productivity growth appears here to be more rapid productivity growth — hardly a useful insight.

Some of the slowdown in output growth, perhaps a third, is due to the anti-inflationary policies after 1973. And more of the same is in sight. To the extent that we can adopt more efficient anti-inflationary policies, such as tax-based incomes policies, we can temporarily grow faster and reap slightly more productivity growth. This bonus seems to me yet another in a powerful list of arguments for more innovative policies to fight inflation.

b. A more subtle question is whether a generally higher level of demand, a perpetual state of tight markets such as exists in Eastern Europe, will lead to more or less rapid total factor productivity growth. People have worked hard to find such an effect, but no convincing evidence has turned up. If a larger market is a spur to invention, so are hard times. Failing such evidence, I don't think we can turn to productivity growth as a reason to run a perpetually overheated economy.

c. One of the most familiar litanies is that productivity has been hurt by stop-go economic policies. Nowhere is there greater confusion than on what "stop-go" means. We must separate out the variance of policies (hitting the brake or accelerator) from the variance of outcomes (changes in the speed of the car). The reason we engage in stop-go policies is to *reduce* the variance of outcomes. Every sensible person would certainly desist from stop-go policies if that would stabilize output and inflation. But many of us feel that a constitutionally imposed balanced budget or a fixed money growth would lead to a more unstable economy.

It would seem obvious, then, that a successful stop-go policy would

[4] This statement does not mean that the productivity slowdown has had no effect on inflation.

create greater predictability and certainty, would lead to lower risk premia on investment, and would improve productivity; an unsuccessful policy would do the reverse. Thus the goals of stabilization policy are coincident with those of productivity policy.

A different question is whether economic policy since the New Economics has been stabilizing or destabilizing of output variables. Its *intent* has surely been to stabilize output, but reviews on its success are mixed. The greater variance of output since 1973, however, has surely been largely due to nonpolicy shocks rather than policy mistakes. And, in any case, the increased variance in output since 1973 cannot explain the deterioration in productivity growth, for the variance is smaller than the interwar or early postwar period.

d. A final set of issues in demand management concerns the composition and possible bias in policies. These are closely related to supply-side issues, but it will be useful to raise them briefly at this point. The major issue in the composition of policies concerns the division of labor between monetary and fiscal policy. It has been a common (and accurate) complaint that monetary policy fights inflation while fiscal policy fights recession. The result has been that "Q" has fallen from 1 in the late 1960s to .65 in 1979, and that the real cost of equity capital (the corrected earnings-price ratio) has risen from 7 percent in 1970 to 12 percent in 1979. At the same time federal government outlays as a share of GNP have risen almost 1 percent. The institutional characteristics which lead to anti-investment and anti-productivity cyclical responses are well-known (the Congress responding to political pressures and cycles while the Federal Reserve System puts a greater weight on a stable currency).

There are hopes that the bias in demand policies might improve. The survival of the fragile Congressional budget process is clearly extremely important to some kind of fiscal discipline. A constitutional limitation of Presidential term to six years would help insulate the other branch from election-year economics.

The movement to floating exchange rates has helped free monetary policy from being hostage to exchange markets, but further reliance on intervention rather than interest rates could allow further pro-growth monetary policy.

Taken together, improved demand management policy appears to be one modest element in improving our productivity performance. Many of the suggestions raised here are worthwhile on their own, and the effect on productivity adds some weight to the argument. But I doubt that more than a few tenths of a percent additional growth can be squeezed out of the feasible set of reforms of demand-side policies.

3. *Investment*

The central policy response to a productivity slowdown is to set in motion policies that change the savings and investment patterns of the nation. Obviously, this is an extremely complex issue and we can only touch on the major issues.

The first issue, discussed at length above, is whether the United States should save more as a result of the productivity slowdown. My tentative conclusion is that if investment and growth policies were well-designed before the slowdown, *the nation should save and invest a smaller fraction of its output after a decline in productivity.* This conclusion is reinforced by the observation that the rate of return on investment has declined in the last decade or so.

Given our conclusion that we should save less, we must look elsewhere to argue that the policy response should be to increase investment incentives. The first place to look is in market failures. That is, we might feel that our economy has been undersaving all along because of inherent biases in our mixed economy. This is a defensible view, but it has nothing to do with the productivity slowdown. Presumably the urgency of the undersaving problem is less today than a decade ago because the optimal savings rate is probably reduced by the slowdown.

A second potential market failure lies in the fact that slow productivity might per se worsen the market failure; thus if low productivity led to higher inflation, this might raise tax rates on genuine capital income. Aside from the questionable impact of inflation (which has no intrinsic connection to productivity growth) we have found no mechanism that would lead from slower productivity growth to a greater discrepancy between optimal and actual investment.

We might, however, want to proceed in a lawyerlike fashion — asking what would make sense in terms of investment policy if we decided that we did want to save and invest more as a result of the productivity slowdown. We would probably first start by asking where it makes most sense to channel investment, then ask how to raise the additional savings. If I had to list investments in the order of social return, it would be the following: oil production and conservation, R & D, foreign direct investment, corporate fixed investment, human capital, consumer durables, public investment, housing, land, art, gold, mandated regulatory investments. Any pro-growth strategy would probably be well off if it consisted of incentives to augment flows into the first five of the above, and to withdraw flows from the last five or six.

Once we confront the problems of rechanneling national output in such a way, it becomes clear that many familiar solutions are not really an answer. Take generalized pro-savings programs such as mandatory pension plans, lower social security benefits, replacing income with consumption taxes, lower taxes on property income or capital gains, or more generally a shift in the mix from tight money/loose fiscal to loose money/tight fiscal. These policies will increase savings and investment in general, but their effects will be generally spread from oil conservation to higher gold prices. Because the fraction of the capital stock that resides in the high-yield investments is relatively low, the average yield on changes in the composition of output from consumption to investment may be small. Thus generalized anticonsumption policies should be pursued only if we are convinced that the freed resources

will end up in energy conservation, R&D, or corporate capital rather than in low-yield investments such as gasohol, South African gold mines, the M-X missile, or solar-heated swimming pools.

Because I am skeptical about generalized pro-savings policies as a way of improving our productivity performance, I would instead attempt to retarget flows to investment by selective fiscal policies. The most attractive in my mind are:

1. An energy policy that has a very high reward on incremental production or conservation of oil (more on this later).
2. A program of channeling resources into research and development. The most productive way to do this would be to legislate a general tax credit for R&D, perhaps providing special incentives in those sectors (energy, pollution control, corporate capital) that appear to have the highest yield on research.
3. A program of assisting foreign direct investment, both through selective changes in regulations, a revamped DISC, and pursuit of a multinational code for investment and services.
4. The largest program would be a program of investment incentives for corporate investment. This should certainly consist of correcting structural defects in the current investment incentives system, such as removing the bias of the investment tax credit toward short-lived investments and its extension to structures. The appropriate way to correct inflation's distortions on depreciation would be to move toward allowing depreciation allowances to take a replacement cost basis. Many of the current proposals (the "10-5-3" proposal) are extremely poorly designed to correct the distortions in today's tax code and will further subsidize investments in the real estate and commercial building market — hardly a way to improve productivity. A more radical approach would be to restructure the corporate income tax system, for capital is surely more heavily taxed there than is efficient. Two approaches that would reduce the inefficiencies from heavy company taxation are, first, a program of full integration of corporate and personal taxes and, second, moving toward higher rates of indirect taxation.
5. Finally, I am impressed by the extent to which the nation is depreciating its stock of intellectual resources. The crumbling of the ivory towers due to deferred maintenance, and the declining relative incomes of those in the academy, can hardly be a healthy sign for basic science and technology over the coming decades. Increased support of basic research, and the institutions that nourish research and produce researchers, must surely be central to an increased investment program.

At the same time, we should attempt to correct some of the major problems that arise in the current system that gives a preference to low-yield investments.

1. The most important defect is the enormous tax preference to owner-occupied dwellings, where interest and taxes are deductible but imputed income is not taxed. The recent move toward allowing borrowing for mortgages at the state and local interest rate is, as well, an extremely dangerous trend. A major plank in the platform of those who want to make a more efficient use of our investment resources should be to reduce the incentives for very low-yield investments here.
2. Movement toward an indexed tax system, in which taxes at full rates are levied on real returns, would remove some of the distortion that allows sterile investments in gold, art, and land to become so attractive.
3. Regulatory reform, discussed below, is a major possible source of productive investment. It appears that we are channeling an excessive amount of new investment into some sectors or technologies. Complementarity of mandated with new investment, together with the grandfathering of old capital, is currently a major impediment to productive use of investment resources.

4. *Energy*

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 experienced a productivity deceleration of 10 percent and utilities of 7 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.

The major controversy concerning energy's impact on productivity has been generated by the capital-energy complementarity issue. The issue can be quite succintly 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 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 leads 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 0.80 to 0.87 percent. (In a more complete model, Hudson and Jorgenson estimate that the four-year effect was 0.6 percent annually.) It is hard to see how this discrepancy could generate much controversy.

In fact, this capital-complementarity controversy has been a smokescreen 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, 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 substitutes 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, we will be progressively replacing high cost oil with high cost capital and labor. The slower the adjustment, the longer is the period over which the productivity drop is spread.

Turning to the policy aspects, the adjustment speed presents an interesting paradox about efficient energy policies. It is generally agreed that one of the central goals of energy policy is to accelerate the replacement of the energy-inefficient capital stock with fuel-efficient capital. We have for this reason taken extensive steps to subsidize replacement of old oil and gas equipment and regulate the energy performance of autos, houses and appliances. Paradoxically, these policies are *anti-productivity* measures, for they accelerate use of energy-efficient but labor-inefficient technologies. In today's tight world oil markets, the best energy policy is one that will, on the margin, lower potential output. By driving the marginal product of energy beyond the world price, industrial countries can reduce oil prices and improve their terms of trade. Thus while national output may be reduced, national income is increased.

As we look forward to the 1980s, what are the needs for energy policy and how do they relate to productivity policy? My view is that three features of energy policy are necessary to avoid energy's drag on our real incomes.

1. The first and key policy is to assure that energy price signals facing consumers and producers reflect social costs. In my view, social costs of oil consumption are around two times the world price because of the effects of increased consumption on world oil prices, terms of trade, inflation, and macroeconomic policy. All industrial countries should seek a harmonization of oil import or product taxes (not just on gasoline) rising to a level of $30 per barrel. Indeed, such a policy should be the first item on the agenda of every major international policy conclave.

As mentioned above, this policy will hurt rather than help productivity. In extractive industries, marginal products will fall even further than in

Figure 1, and in the rest of the economy will scramble to scrap old oil-inefficient capital. Yet over the long run, the major danger to our economies is that our output increases will be drained away as tribute money; since 1973 one-third of our output increase has been lost to increased value of oil imports.

2. An aggressive energy policy like that proposed above will involve enormous transfers from consumers to oil producers and the government. Careful thought should be given to the recycling of the revenues. Experience in the United States is that at least a fraction of the revenues will be devoted to marginal uses (gasohol being perhaps the most inefficient — indeed, counterproductive — use on record). If the tax revenues are completely wasted, then a first approximation suggests no gain from the tax-based energy policy. Put differently, the main gain from high energy taxes is that the oil expenditures become domestic income rather than foreign income. If the domestic income is not turned to useful purposes, then the potential gain is not realized.

One way in which oil taxes can be efficiently recycled is by lower prices, e.g., through subsidies, tax credits, or lower value-added or social insurance taxes. In these cases some of the inflationary costs of high energy taxes would be removed.

A second route would relate quite directly to productivity. Today, many analysts feel that there will be large "supply side" effects of lower taxes on capital and labor — lower overall taxes would stimulate the supplies of capital and labor and would reduce welfare losses from differential taxation. Thus, one of the possible advantages of heavy energy taxes, together with lower taxes on capital and labor, would be that this fiscal reorganization could actually enhance the efficiency of our tax system overall. More generally, one of the key productivity-raising measures we should keep in mind is to improve our fiscal system — to raise a larger fraction of the necessary government revenues by taxing goods we want to discourage (oil consumption or pollution) and a smaller fraction on those activities that we want to encourage (supply of labor and capital as well as production of useful goods and services).

3. Finally, other points in our productivity discussion complement energy policy. The most important is regulatory reform. A recent study by the Department of Energy concludes that the sum total of our key energy policies (e.g., tax preferences for drilling, Jones Act, natural gas decontrol, incremental pricing, windfall profits tax) is a wash with respect to oil prices and oil imports; yet they clearly cost an enormous amount of effort and expenditure. One of our first tasks should be to dismantle many of these conflicting regulations. A second area is in social regulation. Nowhere do the inefficiencies of our current regulatory structure appear heavier than in energy. We have excellent case studies — such as in new source performance standard (NSPS) for steam electric plants — where it is clear that we have "gold-plated" our regulations. The original NSPS proposed a standard that actually yielded higher population-weighted sulfur emissions than a less cost-

ly standard. In addition, oil imports were projected to be 300,000 barrels a day higher in the original case. It seems clear that by moving toward sulfur taxes, more modest goals, and putting these in a regulatory budget framework, we could save considerable money and make more productive use of our resources.

A second area where other policy reforms could assist energy policy is in R & D. The history of energy R & D from the breeder reactor to the Concorde is that government has been calling the plays from the bench, and calling them badly. We would be well served by a policy which shifts more of the energy R & D funding to the public, and more of the detailed decisions on loops versus vats or underground versus above ground retorting to entrepreneurs. The R&D tax credit suggested above — perhaps higher in energy — could speed the transition to a more sustainable energy system.

5. *Regulation*

Attempts to change the regulatory environment in the United States are high on the list of many who wish to improve productivity performance. To some extent, particularly for the business community, this emphasis arises because much of the regulatory system was an anathema to begin with, and the productivity slowdown is a fine excuse to reverse or abolish programs which were never palatable. Even though the business attack on the regulatory process may be as much ideology as economics, there are, in my view, sound reasons for trying to improve the regulatory process as a part of an attempt to improve the productivity performance in the United States. In what follows I will outline three major areas of reform that might contribute to reviving our lagging productivity.

In discussing the regulatory process, we must distinguish between the older economic regulation (which prescribes pricing or conditions of entry) from the newer social regulation (which is broader and regulates the externalities of pollution, health, or worker safety). We have made considerable progress in the last few years in dismantling the economic regulatory apparatus — witness major legislation on the books for airlines, security markets, railroads, financial markets, and natural gas, as well as prospective loosening of regulatory constraints in trucking, oil, and communications. The first set of policies would be to press further and faster in removing or revising the regulatory constraints in economic regulation. Aside from those in the mill, we should press for further reforms in the area of agriculture (dairy and milk as well as setasides), energy, and local utility rate reform.

The other side of the regulatory story is, unfortunately, much less encouraging. The last 10 years have witnessed an explosion of social regulation. By most measures, we will probably see extremely large mandated costs over the next decade as the regulations recently promulgated begin to bite. Estimates of the 10-year cost of major regulations promulgated in the last four years run in the $300-600 billion range.

The high cost of implementing the new social regulation is not per se a reason to stop or slow these programs. There is disturbing evidence, how-

ever, that the social regulatory process is quite inefficient.[5] Robert Crandall's paper touches on some of the important inefficiencies in the process, particularly the bias against new investment. A broad overview of the inefficiencies in the regulatory process suggests that two major areas are in need of reform: inefficient regulatory techniques and the lack of a budget constraint on regulators.

The inefficient regulatory techniques are discussed in the Crandall paper and have been widely criticized by economists. The most significant problem is the use of quantity regulation and engineering standards rather than price regulation or performance standards. In the example of the controls of sulfur emissions, it would be much more efficient to use emission taxes rather than emission limits as a way of reducing emissions. OSHA generally specifies equipment to be used rather than health effects to be reduced. Examples where inefficient regulatory techniques are used are legion in the area of social regulation, yet the movement away from inefficient quantity regulation toward more efficient price regulation has been extremely slow. One of the major regulatory reforms that might significantly lower the costs of attaining our regulatory goals would be to improve the techniques. Some examples are:

- In air and water pollution, substitute emission charges for emission limits.
- In automobile emissions, allow tradeoffs between emissions as a first step and then institute an emission tax on new and old vehicles.
- In the area of worker safety, substitute injury taxes and mandatory insurance policies for specified work practices and engineering requirements.
- Substitute a wellhead tax for price controls on natural gas.
- Substitute performance for specification standards wherever possible.

None of these ideas are new — in fact they are so old they are practically forgotten. Again, to the extent that we would like to use the productivity slowdown as an occasion to retune our economic engine, these old ideas should be part of the overhaul.

In addition to the inefficiency of the regulatory tools in social regulation, there is considerable evidence that the political process which sets the goals or stringency of regulation is defective. More or less independent regulatory agencies implement virtually all regulation in the U.S. economy. While in earlier days this independence might have been necessary to protect the integrity of the political process, the pendulum has swung too far. Regulators are acting in the place of the legislative and executive branch in allocating tens of billions of dollars a year — indeed, the figures given above suggest even more — without the political accountability that we expect in the tax and expenditure system. Put differently, regulators function without

[5] This section draws on many of the ideas in a book under preparation with Robert Litan, *Toward Sensible Regulation.*

an effective budget constraint in making their major decisions. Recent history shows many examples (sulfur scrubbing, aid for the handicapped, ozone standards, oil pricing and entitlements allocation) where regulators allocated many billions of national output without involving the other two branches of government sufficiently in setting the goals, the standards, and the dollars to be allocated.

There are several policy proposals today for restructuring the regulatory process. (A fuller discussion is contained in the Litan-Nordhaus book.) These proposals can be broken into two parts — assuring greater political accountability and imposing a budget constraint. Imposing greater political accountability means that the President and the Congress should have greater say in the detailed decisions, particularly the costs, of major regulatory actions. We have witnessed a very modest increase in Presidential oversight in the last four years, but regulators remain largely autonomous. One proposal to impose greater political control is the idea of a "legislative regulatory agenda." Under this proposal, all major regulations must be approved by being part of an annual agenda that is enacted. By requiring that regulation be included in the agenda, regulators would be prodded to assure that the overall economic impact of their actions was reasonable, that they had weighed appropriate costs and benefits, and that major political actors were generally in accord with these actions.

A more radical proposal is the "regulatory budget." Under this proposal, the legislative agenda would be supplemented by a quantitative cost control system. Each regulatory agency would be given an annual budget for new regulations, and it would be required to keep its total actions within this budget for a given year. Thus the Environmental Protection Agency might be forced to limit the costs of its new regulations to a total of $30 billion in a year; the budget constraint would force the agency to design cost-effective regulations and to exercise restraint in setting its regulatory goals.

These three proposals are among many that are before the Congress today. Clearly many details must be worked out, particularly in the area of social regulation. I am convinced that by pushing forward on each of the three routes of regulatory reform discussed here, many of the chilling effects of regulation on productivity could be alleviated or reversed.

* * *

Having reviewed specific policy responses to the productivity slowdown, one further point remains to be made. Few of the recommendations that are made arise directly from the productivity slowdown. They represent sound economic management. We should do them in 1980, but then we should also have done them in the mid-1960s before the productivity slowdown began. Although the economic climate may change, principles for construction of sound shelters endure.

APPENDIX

In fact, a great deal of implicit theory lies behind the deceptively simple diagram in Figure 3. What I have in mind in order to make this discussion rigorous is something like the following.

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 $L(t)e^{ht}$ is the effective labor force, which is growing at rate $g = n + h$. Gross output per worker is $e^{ht}f(k)$, where k is the ratio of capital stock to effective labor force K/Le^{ht}. Capital depreciates at the exponential rate δ. Finally, let $r(t) = f'[k(t)] - \delta$ be the net instantaneous return on capital and $R(t) = \exp\left[\int_0^t r(v)dv\right]$ be the t – period rate of return. Then a unit reduction of per capita consumption at time 0 will yield $R(t) \exp(-nt)$ units of per capita consumption at time t. Define "income," $\bar{c}$, as that level of consumption that is indefinitely sustainable, so $\bar{c} - c(0)$ is per capita "savings" at time 0.

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 $\int u[c(t)] \exp(-\rho t)\, dt$ where $u(c)$ is the one-period utility of consumption, ρ is the constant pure rate of time preference at which utility is discounted, and the elasticity of marginal utility with respect to consumption is $u''c/u' = -b$.

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

Discussion

Robert M. Solow*

The productivity question turns out to be more delicate than you might expect. For a start, the underlying time series is pretty irregular, as a look at Nordhaus's Figure 2 will show. Remember: that time series has been smoothed twice, once by removal of an estimated business-cycle effect and again by a six-year moving average. The extent and timing of the productivity slowdown can not be determined with precision from so ragged a history. Different authors, different data and different methods can, and do, give different results. One of the merits of Nordhaus's paper is that he brings to bear that neglected econometric weapon, common sense, and tries to state clearly what a reasonable person might think is there to be explained and, perhaps, to be made the object of policy. In the course of laying all this out, he raises some basic questions and slaughters some sacred cows. On most of the issues I am in sympathy with Nordhaus, though I do have a few minor differences of opinion and there is one more cow I am tempted to ship to the knacker. Since I am basically comfortable with the paper, I think I will do the unexpected and actually discuss it, more or less sequentially.

First of all, let us return to Figure 2 and the underlying facts. I think it is very useful to take a look at a period longer than a couple of decades, because I am a little doubtful about the use of growth-accounting methods with short-run phenomena. There are two elements in the generation of Figure 2 that might be worth talking about. One is the method by which cyclical effects are removed. If I understand the technique, it has the probably undesirable implication that a sustained increase of 1 percent in the annual growth of output generates a sustained increase of .25 of a percent in the annual growth of productivity. You would expect that coefficients on current and lagged output growth would add to zero; otherwise the regression equation claims that an increase in the rate of growth of the labor force, translated into growth in output, automatically elicits faster growth of productivity. One can understand why an unrestricted regression might have coefficients adding up to a positive number — for instance the reverse causation from productivity growth to output growth. I would feel a little better if the business-cycle correction had been done in a way that enforced neutrality, but it may not matter much for the end result.

My second question about Figure 2 is this. The last observation plotted

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is for 1979. If that is a six-year moving average, it can hardly be a centered six-year moving average. It has to be a trailing moving average. If I am right, then the plot for 1979 is the average of the readings for the years 1974–1979 inclusive. That would more naturally be plotted at New Year's Eve 1977. In other words, one might read Figure 2 as if the graph were shifted three years to the left (or the time axis three years to the right). That is interesting because the graph as it stands is compatible with dating the productivity slowdown from 1962. Translated, that would mean from 1959–60, a dating which would suggest wholly different cause-effect chains from those discussed here. I am not advocating such a view; I mention it because I am dubious about sudden breaks in the productivity trend, and also because it drives home how ill-defined the slowdown is. If productivity had risen a bit faster in 1967–69 or 1971–73, we would probably not be talking about a productivity slowdown in the second half of the 1970s. If you think of Figure 2 as a quality control chart for some industrial process, it would take very little amendment of the figures to keep its right-hand end within the control lines that are supposed to alert the quality-control engineer to a shift in the underlying process.

However that may be, I am, like Nordhaus, willing to accept the existence of a productivity slowdown. Let me now turn to its sources. I have no serious argument with Nordhaus's rough allocation in Table 4. If I had to pick nits, I would query the .20 of a percent allocated to regulation and the same amount allocated to higher energy costs. I presume that the diversion of capital equipment to meet pollution and safety standards is already accounted for in the allocation to capital, though I am not sure. All I mean to say is that the chilling indirect effects of regulation leave me, so to speak, a little cold, only because they are too intangible to evaluate.

The productivity effects of increased energy costs are a matter of controversy. I am inclined to leave that issue to the experts, of whom Nordhaus is one and I am not. My only reason for entering a query is that later on in the paper Nordhaus does a few calculations using a Cobb-Douglas aggregate production function in which energy appears as an input with an elasticity of 0.10. That seems quite high; Berndt's paper quotes a number less than 0.02 for manufacturing (relative to gross output, more like 0.05 relative to value-added), but I do not know what kind of adjustment to make for the rest of the economy. No matter; I am sure the energy issue will be debated and I have no fixed opinion.

The other aspect of Table 4 that seems worth a word is the small allocation, .10 of a percentage point of deceleration, to labor. The productivity slowdown is not a labor problem; that is also the message of the Perloff-Wachter paper, and I agree with it. Apparently the negative age-sex effects are fully offset by favorable education effects. I have occasionally wondered about all this. Presumably wage differentials related to age and sex reflect a mixture of discrimination and a return to experience and training. If it were all discrimination, age and sex would be irrelevant to productivity, more or less by definition, except for minor adjustment costs like doors on locker rooms and company time spent coming on strong. If stratifying employment

by age and sex is supposed mainly to capture experience and training differences, then it would seem preferable to measure those differences directly. I presume it can not be done, or else it would be done. So I am left with a nagging wish to know if those age-sex effects on productivity, on unemployment rates, on the Phillips curve, are for real.

For later reference, note that Nordhaus attributes only .10 of a point of the slowdown to a shortfall of Research and Development, though he later on expresses the nostalgic feeling that they don't make inventions like they used to. Evidently Professor Nordhaus is not adequately in awe of the achievement represented by the transistorized earphone radio, Astroturf, or the slam dunk. Opinions differ.

In his broad division of the sources of productivity slowdown, Nordhaus gives 65 percent of the weight to what he calls "depletion." I have no major difference of opinion here, although I do think that he interprets "depletion" rather broadly. Of the examples he gives, the decline in productivity in the extractive industries probably owes a lot to mine safety regulation, especially in coal mines (which sounds to me like productivity well lost), the decline in the return on corporate capital, if it is indeed noncyclical, need not represent depletion of investment opportunities unless there is some reason for diminishing returns to have come on with a rush in the 1970s, and the decline in the return on R&D spending is hardly a solid enough finding to deserve an explanation.

I have a general point to make here. I know he doesn't believe it, but the way Nordhaus has organized his thoughts suggests that the correct policy response to the productivity slowdown somehow involves finding out what caused it and then undoing the cause, unless it represents a change in tastes. But that need not be so. There is nothing irrational in discovering that factor X was the cause and responding by pushing harder on factor Y; if higher energy costs have reduced the rate of productivity growth, we might rationally conclude that we can no longer afford inefficient regulatory policy.

I do think it is very important to absorb Nordhaus's conclusion that some sources of productivity slowdown are optimally met by saving and investing a smaller fraction of output. He is right about that, and the opposite reflex is one of the sacred cows he leaves by the wayside. I am not sure — and neither is he, I imagine — that it is generally correct to model all depletion phenomena as a fall in the exogenous rate of labor-augmenting technical progress. But there are other stories in which it remains true that the saving-investment share ought optimally to fall as the growth rate tapers off. There may well be opposite cases too; the important thing is to realize that the optimal policy response does not always preserve the growth rate.

The second sacred cow dispatched by Nordhaus is the undersaving argument. I think he is right in what he says, and so I will not dwell on this point. There is a much older question, which has nothing to do with the productivity slowdown but does relate to growth-and-investment policy generally: how to make sense of the apparent willingness of people to save at interest rates considerably lower than the pre-tax rate of return on corporate capital. But that would take us away from the main issue.

The third cliché Nordhaus attacks is the one that blames the productivity slowdown, like everything else from the high divorce rate to the failure of Red Sox pitching, on the recent inflation, and concludes that, if only we could stop the inflation, productivity would revive and Mike Torrez would be able to get the side out. Nordhaus doesn't believe it, and neither do I.

Now I come to the sacred cow that Nordhaus leaves standing; I don't exactly want to knock it over, but I do want to suggest some healthy skepticism. I have in mind the focus on R&D spending.

To begin with, academic people should be wary of promoting research spending as a cure-all for productivity problems. It sounds too much like the Machinery and Allied Products Institute proclaiming that it is our patriotic duty to have an investment boom. It may be so, but I would rather hear it from a less interested source. Of course, if we are sure of our ground, then we should not be inhibited from speaking the truth just because it is good for us personally. How strong is the evidence?

I pointed out earlier that Nordhaus attributes only .10 of a percentage point of the 2 plus percentage point slowdown to diminished R&D. That is in Denison's ballpark, but considerably less than John Kendrick's estimate. However, my own dictum comes into play here: R&D could be the cure for what ails you even if it didn't cause the disease. (In a recent paper, by the way, Zvi Griliches remarks: " . . . it is unlikely that the recent productivity slowdown can be blamed primarily on the R&D slowdown. If anything, causality may run in the other direction." Griliches imputes about 0.14 percentage points of the productivity slowdown to lagging R&D, close to Nordhaus's figure.)

Griliches and Kendrick, and no doubt others, proceed by calculating a "stock" of R&D, a cumulation of real current expenditures less some sort of depreciation of old knowledge. They then treat this stock as a factor of production in the ordinary growth-accounting framework. Griliches gives it an output-elasticity of 0.06; Kendrick appears to use a larger estimate, say 0.10 or 0.12. It is a reasonable approach and I do not know of a better one. But it is hardly self-evident that productively useful knowledge behaves like a stock, is added to by R&D spending with some specifiable lag after the money is spent, and has a marginal product like a conventional input. It may well be so, but I am not comfortable making promises based on that model. I am especially worried by proposals like Nordhaus's blanket 70 percent subsidy on energy research and 30 percent subsidy on development. It is true that he puts the social value of new energy sources very high, and he may be right; but one does fear that a blanket 70 percent subsidy would buy some mighty gold-plated research with a mighty low payoff, performed in some mighty plush offices.

Many, indeed most, of Nordhaus's proposals strike me as excellent ideas. A lot of them would be excellent ideas even if there had been no productivity slowdown — for example, moving to more effective, less conventional, anti-inflation policies so that the whole burden does not fall on tight money, or shifting incentives so that land, gold, and art become less attrac-

tive assets. It would be nice if we were pushed into doing these desirable things just as a way of coping with the productivity problem, even if there is no direct causal connection.

On the productivity slowdown itself, I continue to counsel agnosticism about causes and effects. At a conference sponsored by my favorite Federal Reserve Bank, it is only right that I should tell you about a wonderful *graffito* that I saw the other day in the Boston financial district, not far from the Boston Fed. Someone had spray-painted across a large sheet of plywood covering a window: "I don't know. I just don't know."