Information Technology and the Service Sector: A Feedback Process?

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"By virtue of this concatenation of processes the modern industrial system at large bears the character of a comprehensive, balanced mechanical process ...The higher the degree of development reached by a given industrial community, the more comprehensive and urgent becomes the requirement of interstitial adjustment." Thorstein Veblen, The Theory of Business Enterprise (New York, 1904), p. 16.

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Toward Overview of the Conference

A near impossible task that falls to the ultimate speaker at a conference is that of encapsulation and characterisation of what has gone before. Where the materials that have been provided by the other authors are as rich and varied as those that have been offered to us here, any evaluative synopsis must inevitably be distinguished primarily by the importance of the many things it omits. What follows can be taken to be a clear illustration of this point. Moreover, any attempt to summarise, paper by paper, what the contributors to this conference have said so effectively would be an exercise in redundancy. Consequently, the discussion that follows will confine itself to general themes that emerged, generally leaving the papers to speak for themselves.

It seems to me that from the rich body of materials that the comference has provided, two primary themes emerge. First, there is the sheer magnitude of the pace and degree of change that characterises the contribution of the output of information services to the remainder of the service sector and to the economy generally. The second theme was the availability of scope for progress in the measurement and evaluation of these changes and the relationships that underlie them.

I turn first to the changes themselves. So vast are these developments that they literally elude the ability of our minds to encompass them. Even where they can be described and quantified, the descriptions remain
mere words and numbers without tangible substance. To illustrate my point, it may be reported from Maddison's widely

used estimates [1982] that in the 110 years since 1870 output per person hour in the U.S. has risen some 1100 per cent, while exports have gone up more than 9000 per cent, both in real terms. One can point out that nothing remotely resembling this has ever been experienced in human history, and offer other interpretive comments. But in the end these numbers remain so mind boggling that they continue to elude comprehension. Indeed, the overwhelming magnitude of the changes has been sufficient to make us blase about the unprecidented explosion of developments. No longer do people stop to stare up at passing airoplanes as was common when I was a child. Instead, one hears of people tiring of their home computers, which they had purchased casually for use as expensive pin-ball machines, serving incidentally as space-wasteful typewriters.

It is no small accomplishment of the writings in this volume that, despite these impediments ,they succeed in conveying to the reader some sense of the profundity of the revolution in whose midst we now find ourselves. This is perhaps clearest in the two papers which report on types of services for which the effects of the information explosion has been most drammatic: trade in services, as described by Geza Feketekuty and Kathryn Hauser, and financial services (and thier regulation) which are dicussed by Almarin Phillips and Mitchell Berlin.

One of the many revalations of the trade paper is the extent to which varieties of services previously all but unexportable, now enter international trade regularly and as a matter of routine. To add to the examples of the paper an illustration come to be expected of me I cite theatrical performances, which once could be exported only by physical movement of the

actors, an undertaking formerly sufficiently arduous and costly to elicit notice in the newspapers when it did occur. Today, who would remark upon the trade of performing sevices that occurs when American viewing of Masterpiece Theater is balanced off by the intrusion of the latest episode of Dallas into the Englishman's castle?

Add this example to the internationalistion of stock exchange trading, of data bas accumulation, and even of blueprint drawing, as described in the Feketekuty-Hauser paper, and some picture of the magntude of the changes under way begin to emerge.

Similarly, the paper on financial sevices provides what many may regard as new revelations. A startling example is the way in which the new technology adds to the avenues available to those who would legaly avoid the reguatory ministrations of the monetary authorities. The ever expanding array of means for legitimisation of the black markets is reminiscent of the products of the ingenuity of those who in an earlier age were determined not to be stymied by chastity belts, giving rise to the felicitous remark that love laughs at locksmiths. The main moral seems to be that a product of the information revolution which is by no means its least negligible is that, rather than serving as the ally of the regulator in his attempts to interfere with the workings of the market process, it has given new strength to the market mechanism and helped to reduce its vulnerability.

The three fine papers on applications of the products of the information activities to services in which the current consequences may be only slightly less drammatic, nevertheless make a similar point, that the effects, current and prospective,

are ,by any resonable standards, to be judged to be spectacular. That is clearly true of the field of health care so well described by Richard Scheffler, of insurance, knowledgably reported on by David Young, and the cities and their retailing facilities analyzed by George Sternlieb and James Hughes with the effectiveness for which they can be relied upon. The main message from all this is that the information activities--the "production and distribution of knowledge" as my deeply missed collague, Fritz Machlup so aptly described it, create uphevals , not only in manufacturing and agriculture, where effects are commonly recognized, but also in the service industries including the information services themselves.

The second major theme of the conference, the availability of promising opportunities for measurement and analysis of the developments that have just been discussed are,perhaps almost equally exciting and even more surprising. In a field where many have despaired of the possibilities for fruitful and rigorous research, it is a revelation to see demonstrations of what can actually be accomplished. Timothy Bresnahan's immaginative and effective forray into the theory and practice of measurement of what had previously been thought by many to be unmeasurable, and Charles Jonscher's creative modelling of the interactions of information services and other economic activites amply document how much can be accomplished in these arenas. I am confident that their pioneering efforts will be followed by many others once it is recognize how well the beginnings of the road have been explored.

The richness and profundity of the other contributions to this conference clearly have complicated my task , so far as it entails summation. At the same time it makes life easier for me because it relieves me of the sense of responsibiliy for further significant additions to the substance of this conference. I shall, therefore, now proceed accordingly.

Introduction to my main theme

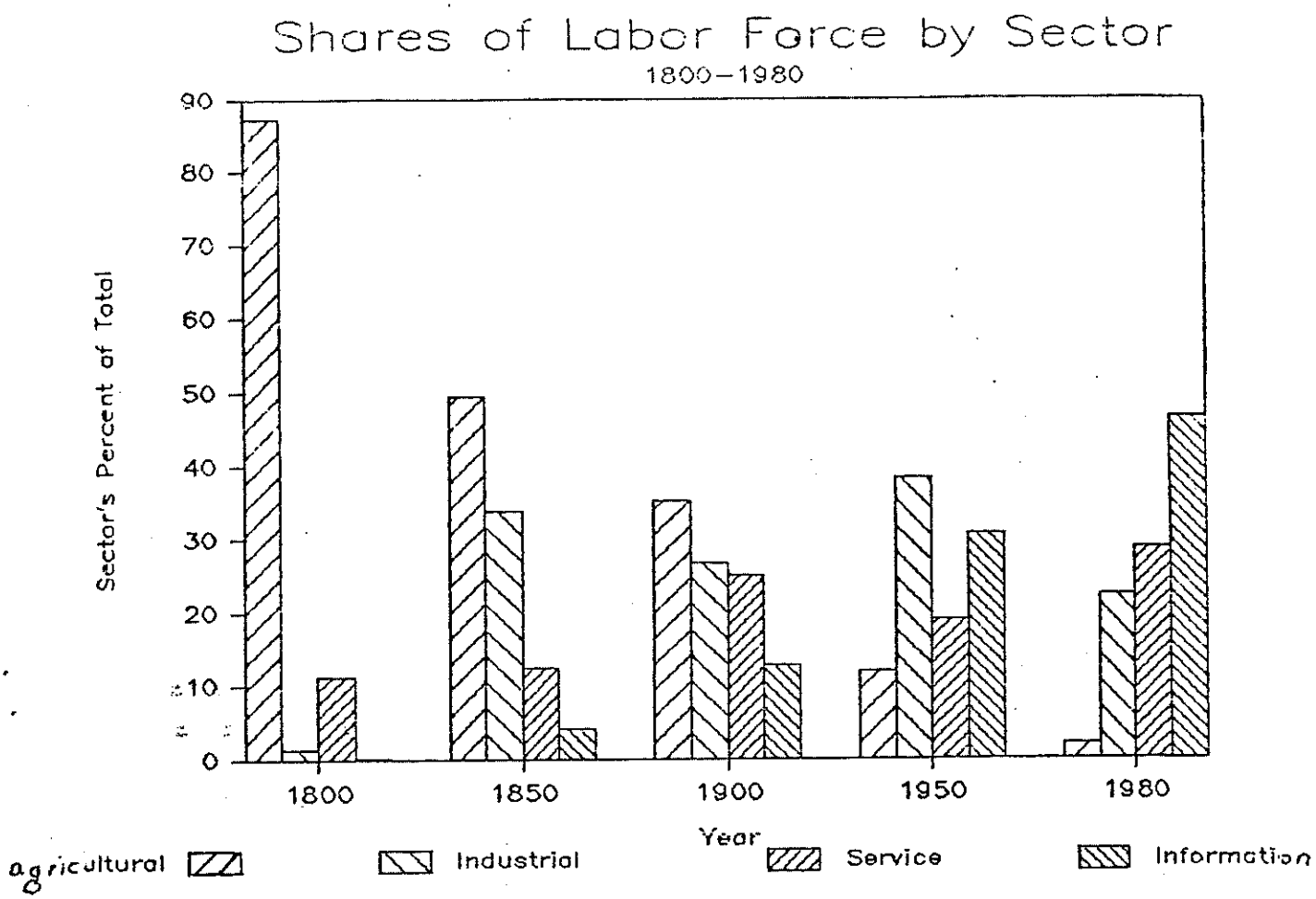
The explosion of techniques for the acquisition, processing and transmission of information has had major effects upon every sector of the economy. The services are clearly among them, though the consequences differ in degree from one service subsector to another. In this paper I will try to offer some indication of the magnitude of the explosion in information activities and will show that this is by no means a postwar phenomenon--that it appears to go back well into the nineteenth century. However, a second observation will lead me to my central point. This is the fact that information provision is itself a service or, rather, a bundle of services, and that this brings us to a two-way relationship with the information sector contributing to the services, while the service sector is the central source of information. Their relationships constitute the basis for a feedback model which raises disturbing possibilities of oscillatory behavior and of dampening of productivity growth.

Information and Heterogeneity of the Services

The burst of expansion of computer based activity is the tangible epitome of the incredible growth in information provision activity. Different industries have been affected to varying degrees and the services have perhaps been those whose responses have varied most. At one extreme is telecommunications which has long been at the forefront of technological advance. While it is not widely recognized, in the last few years computation and telecommunications have virtually effected a merger. Computers constantly communicate with one another by telephone, as is widely recognized. But, at the same time, the telecommunications network has itself been transformed into a giant computer. Switches are no longer the simple objects we once could all describe. Today's "intelligent switches" can quickly determine routes for messages which reduce congestion and queuing problems, and perform a host of other near miraculous tasks. Office switchboards have become astonishingly versatile and sophisticated and even telephone instruments themselves come equipped with mini computers that can record information and act in response to it. It is no wonder that AT&T and IBM have been able to invade one another's territory.

At the other extreme, handicraft services such as live theater, teaching of the humanities and trash collection have all benefitted from computers via word processing, record keeping and research, but the effects are largely peripheral and, fundamentally, the production process underlying these services goes on as it always has. For these services, the cost savings

FIGURE 1



Source: Beniger, The Control Revolution, Princeton, 1984 (unpublished), p. 364.

promised by computers have been negligible, and that has all been part of the persistently low rate of growth in their labor productivity.

The moral of these observations is that it is very dangerous to lump all services together for analytic purposes. If this is shone their diversity is likely to become a source of major error.

On the Growth of Information and other Service Activities

Jacob Viner reminded our profession that the long run is the special responsibility of the academic economists. Let me, accordingly, try to provide a foundation for our discussion by reporting some estimates that extend well over a century indicating the course of information and other U.S. service activities relative to manufacturing and agriculture. Of course, the figures are highly sensitive to the ways these sectors are defined, and the earlier data must, in any event, be taken with much more than a grain of salt. Nevertheless, I believe these figures, taken from work by Professor J. Beniger, provide a reasonably defensible representation of the facts.

Figure 1 shows for the period 1850-1980 the share of the U.S. labor force employed in the various sectors. We see that the transition process has been gradual. Agriculture fell almost linearly from nearly 90 percent of the labor force in 1800 to about 2 percent today. Industrial activity rose steadily until 1950 and then, declined sharply in the postwar period to less than 25 percent of the total. Other services rose steadily until

1950 and then, for all practical purposes levelled off at a bit less than 30 percent of the total. However, information, starting virtually from zero, by 1980 occupied more than 45 percent of the U.S. labor force! Clearly the growing urgency of Veblen's "interstitial adjustments" has had its effects.

However, interpreting these figures, particularly those for industry and services, a crucial caveat must be emphasized. The data in the graph represent relative labor inputs, not relative outputs. The two are by no means proportional. In particular, the long record of productivity growth in industry and its persistent lag in a number of service sectors means that the output of manufactures will not have fallen as rapidly relative to that of the services as has been true of labor inputs. As a matter of fact, data recently assembled by my colleagues and myself (Baumol, Blackman and Wolff [1985]) indicate that there has been no increase in the proportion of U.S. output composed of services--that is, the ratio of number of students graduated, orchestral performances attended, number of tons of solid waste removed, etc., to number of watches, shoes and shovels (etc.) manufactured has, if anything, been decreasing slightly, despite the rising relative share of the nation's labor time devoted to the former. The explanation, of course, is the dramatic increase in manufacturing productivity. Since 1870 it is estimated that U.S. output per person hour has increased an incredible twelvefold (See Maddison [1982] p. 212) meaning that the industrial output of 1870 can now be produced with one-twelfth the labor force it then required. With productivity in many services having grown only negligibly it is clear why the services would

have had to absorb an ever expanding share of the manufacturing labor force just to be able to keep up with the growth in manufacturing output.

Do similar questions arise about the rate of growth of information output? They do indeed, but the reasons there are more subtle. Many information activities contain a vital component which is essentially handicraft in character--teaching, certain types of research, production of computer software are examples. If these pure labor components are a very nearly irreducible part of the information activity or are at least resistant to substantial reduction, then the comparative time paths of their outputs and inputs must grow very similar to those in the personal services generally. In other words, the relative increase in information output, however it may be measured, may well be increasing significantly more slowly than its share of the labor force.

More important for our purposes is the implication about the relative prices (costs) of such information activities with comparatively irreducible labor components. For a key implication of the preceding observations is that, as for many of the personal services, the relative prices of these information outputs will grow higher and higher in comparison with those of industrial products. This is clearly true of education, whose ever rising real cost per student day is amply documented, and the phenomenon has quite appropriately been dubbed the "cost disease" of educational activity. But there is also evidence, more surprisingly, that computation is threatened by similar

prospects. As the costs of hardware have plummeted cumulatively in recent decades, they have come to constitute an ever declining share of computation budgets, leaving the remainder to be taken up by software production and other handicraft services. Some estimates suggest that over the decade of the 70's the handicraft component of computation budgets rose from perhaps 20 percent of the total at the beginning of the period to some 80 percent at the end. This means that in terms of their budgets such information activities are asymptotically approaching the structure of what we may call "quasi handicraft activities" such as violin playing and tutoring of students. As that process continues, the relative costs and prices of computation must rise relative to those of industrial products and those rises must compound and cumulate. Potentially, then, much of information activity is subject to the cost disease. This much I have said before on a number of occasions. What I have to add now is the two way interaction implicit in the process I have just described, and its implications for the future of service activities and for the economy generally.

Productivity and Information: The Two Way Relationship

The production and distribution of knowledge, (as Professor Machlup described the activities that concern us here) have at least two vital roles to play in our economy, the one relating, roughly speaking, to management, the other to entrepreneurship. As the interdependencies among different portions of the economy and even those of individual firms grow increasingly numerous and complex, information and information processing techniques grow

ever increasingly crucial as means to preserve the health of the requisite interstitial adjustments.[2]

But at the same time, information production and dissemination are a prime engine of productivity growth. Indeed, since both basic research and R&D are included within the production of information, it is hard to think of any other comparable and systematic source of growth in total factor productivity.

This is certainly true even of the services most resistant to productivity growth. Here, too, violin playing provides my favorite example. Clearly, the mass media have increased the productivity of the violinist in terms of the number of listeners provided with an hour of music per hour of performance labor, and the dependence of the mass medias' productivity, indeed, of their very existence, on the knowledge industry is equally patent. But even live performance is dependent on the flow of knowledge for productivity improvement. Just think of a violinist living in New York who is engaged to perform in San Francisco. The knowledge industry is responsible for the availability of jet aircraft and for the continuing effectiveness of operation of their passenger transportation network. But such aircraft have reduced the time that violinist must spend just in getting to the location of his work to a small fraction of its magnitude before, say, World War II.

Similarly, the emergence of evermore powerful information technology has increased productivity in services as diverse as food catering, retailing, telecommunications and even research itself.

This, then, is the first half of our feedback relationship. Put rather roughly but not misleadingly, this relationship tells us that an increase in the outputs of the information activities tends to lead to increased productivity in manufacturing and in other services. This much is obvious and it is unlikely to be questioned by anyone.

It is the other side of the feedback relationship, for whose explanation I have already laid the groundwork, that is rather more subtle and less obvious. This second relationship tells us that increased productivity growth elsewhere in the economy tends to impede the expansion of information activities by increasing their relative price through the agency of the cost disease. In sum, while information activities encourage productivity, if my contention is valid, the latter in turn tends to impede the former. With some time lag involved in the process this is sufficient to constitute the feedback relationship to which I have already alluded.

I will next describe the argument underlying the second relationship, and then I will end my paper with a discussion of the implications of such a feedback process.

How Productivity Growth Can Hamper Information Activities

To explain how productivity growth elsewhere in the economy can serve as a handicap to the activities of the information industry let us take computation as our illustration.

I have already indicated why computation (in contradistinction to computers, i.e., to hardware) may find itself increasingly (asymptotically) subject to the cost disease.

But the source of the cost disease of any economic activity is to be found in the relative lag in productivity growth of that activity compared to what is true of the economy as a whole. Over the centuries live violin playing has risen spectacularly in cost relative to watchmaking because in the course of three hundred years the number of watches producible per person year has risen more than one-hundredfold while, despite jet flights to San Francisco, neither labor productivity nor total factor productivity in violin playing is likely even to have doubled in this time.[3] It is primarily activities with quasi irreducible labor components that have suffered from the cost disease and they have suffered from it precisely because the presence of that labor component has by definition prevented rapid rises in their labor productivity.

Now, the relative rise in the prices of the outputs of activities that are laggards in productivity growth is more rapid the greater is the relative rise in productivity in the remainder of the economy. If watch productivity had risen ten times as fast as it did in fact, the relative cost of concerts, i.e., the number of watches that are exchangeable, say, for a subscription to a concert series would now be correspondingly greater than it actually is today.

Thus, as the outpouring of products of the information industry stimulates productivity growth in the economy, it simultaneously raises the relative prices of products of laggard activities, in the comparative dynamics sense of the term. That is, at any time the growth in relative prices of those products

will be faster than it would have been otherwise.

Computation shows just how this happens. Increased productivity in the economy stimulated by a flow of information decreases prices and costs in many areas, the prices of computer hardware among them. But this only serves to reduce the share of the overall computation budget accounted for by such products of technology, and so must devote a greater proportion of that budget to the quasi handicraft portions of computation activity, with the latter threatening to take over almost all of that budget. As that happens, computation costs tend to be driven up along with those of the quasi handicraft services.

This, then, is almost the end of the story behind the second of our feedback relationships. Information activity stimulates productivity growth throughout the economy, but that tends to raise the relative price of computation and other activities.

Only one more step is required. This involves recognition that products of information activities are just another set of inputs into the production process of any firm and, hence, of the economy in general. But, as we know, virtually all inputs have substitutes, so that when the relative price of any input rises, its use will decrease or will at least not grow as rapidly as it would have otherwise. For example, consider a procedure which uses computers to schedule production more efficiently, thereby reducing the number of machines needed for the job. If computation is sufficiently cheap relative to the price of one of the machines, it will be profitable to adopt this process. However, if computation is relatively expensive it will be more profitable to schedule production the old fashioned way, thereby

substituting machines for computation.

Thus, while not denying the likelihood that the explosion of information will continue, I am arguing only that the cost disease has the power to reduce the rate of growth of information inputs into other activities below what it would have been otherwise.

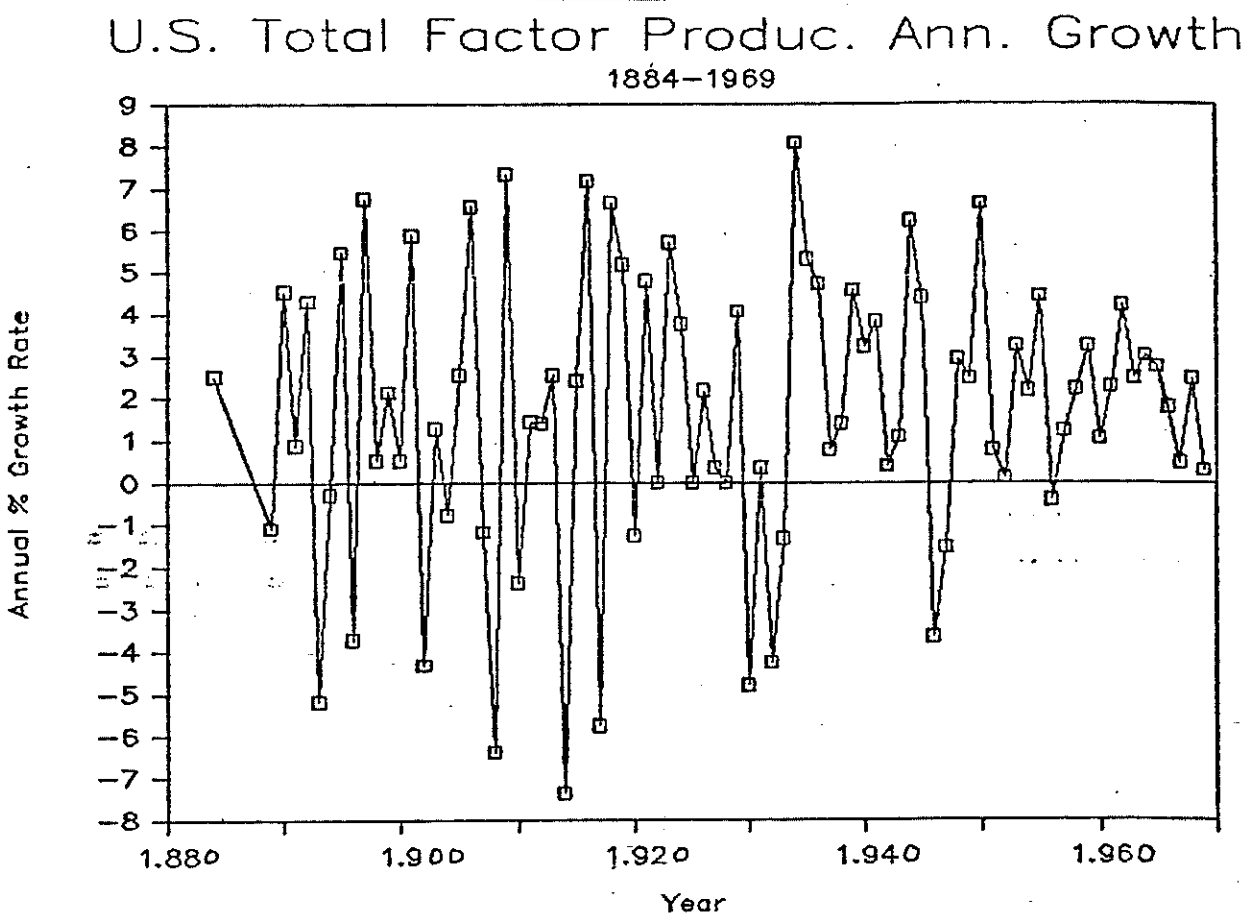
Workings of the Feedback Process

That completes my description of the two basic pieces of the feedback model. Information flows stimulate productivity growth while productivity growth inhibits the production and dissemination of information. The nature of the feedback loop is clear. It is the mechanism of a sequential process in which today's information flow determines (or at least affects) tomorrow's productivity growth and that in turn affects the next days prices of information products and their equilibrium output quantities.

Up to a point the mechanism works in the same way as a cobweb model, and has the same capacity of yielding a time path that is oscillatory and which is either convergent or explosive. It is easy to demonstrate this formally with the aid of a simple difference equation. But it is equally easy to describe the process intuitively. The typical scenario is the following: Let us start our observations, say, in a period in which the outflow of information has grown (relatively) rapidly. In the second period this will increase the rapidity of productivity growth in the sectors of the economy that are not handicraft or quasi

FIGURE 2

FIGURE 2



Source: Kendrick

handicraft in character. Then, in the third period the relative price of information services (among other such prices) will rise and the output of such services will be restricted correspondingly below what it would otherwise have been. In the fourth period the previous reduction in information outflow will decrease productivity growth below its previous trend, and in the fifth period that, in turn, will hold back the relative price and so stimulate the output of information services.

Clearly, such an oscillatory process can continue indefinitely and the data show that this conclusion is not entirely farfetched. Figure 2 shows year by year growth rates of total factor productivity in the U.S. for the better part of a century, calculated from data supplied by Kendrick. (His data on labor productivity exhibit a very similar pattern.) The extraordinary frequency of the oscillations is striking. They seem far more frequent than the economy's business fluctuations. Perhaps a process such as the one I have just described, and others like it, constitute part of the explanation.

The model has other implications. As I have noted, if it really were linear the osscilations would tend to dampen out or explode but neither intuition nor the data I have just shown support such a view. This leads to the inference that the feedback process we are discussing is characterized by nonlinearities--a possibility which is plausible in any event.

Nonlinearities have a number of implications which I will mention but will not go into. They may produce stable limit cycles which can go on "forever" or at least until the underlying mechanism changes. More disturbing is the possibility that they

can introduce a regime of what is referred to as "chaotic behavior" in the difference equation literature, behavior involving deterministic time paths that give all the appearance of being subjected intermittently to very severe random shocks, and which are so sensitive to tiny changes of parameter values as to render virtually hopeless any prospect of estimation of the parameter values of the underlying model by means of statistical observation or, rather, of producing estimates which offer a prayer of robust estimates of the future.

Finally, and perhaps most disturbing, it is possible to show that a process such as ours may well constitute an ever increasing impediment to information flow and, hence, to productivity growth in the economy in general and in the services in particular. If so we may be dealing with a process which is self-terminating or which would tend to terminate itself in the absence of suitable public policy measures. The nature of such policy measures is far from clear at this point.

Concluding Comment: Implications for the Services

I have recently been preoccupied with long term economic data on such subjects as productivity, the composition of the labor force, unemployment and other variables. These have taught me how dangerous it is to generalize from a brief span of observations. Indeed, the long series have caught me out in a number of embarrassing (published) misaprehensions whose details I would much rather leave undescribed here. I can easily produce cases in which 30 years of continuous decline in some key

variable must have suggested that the community had entered a period of irreversible decline, only to have the decline suddenly come to a halt. Similarly, periods of what seem to constitute permanent growth, too, have a way of being terminated suddenly, with little warning. The services have for decades been benefitting from the explosion of information products (which are themselves to a considerable degree, services). This surely has been the characteristic theme of the papers in this conference. But what I have described to you here is some of the relationships which may perhaps underlie this phenomenon. And if the analysis is correct it shows that the phenomenon is not necessarily immune from all dangers. It also suggests a formal structure which can help us to think through the policy options, that is, the things it may be sensible to do in order to deal with those dangers.

Footnotes

[1]Professor Solow once classed economic writing into two categories: "little think" and "big think" -- the latter characterized by broad generalizations and sweeping conclusions. I fear this paper falls somewhat into the latter category, perhaps much more so than is appropriate for a conference such as this. If so, *mia culpa*. It is what I have to say on the subject.

[2]This is the central point in Beniger's unpublished manuscript, which traces the history of the phenomenon and draws out its implications most illuminatingly.

[3]I should explain why I constantly refer to watches in such examples. Aside from the fact that I collect them and know something about their technological history, it is hard to think of *any* other technologically sophisticated consumers' good which has been available and in continuous use before, say, the middle of the nineteenth century. This observation, which may be astonishing when one thinks of it, is just another indication of what the information industry accomplished in just one century.

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