8 INFORMATION TECHNOLOGY AND THE SERVICE SECTOR: A FEEDBACK PROCESS?

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The explosion of techniques for the acquisition, processing, and transmission of information has had major effects upon every sector of the economy. This is clearly true for the services, though the consequences differ in degree from one service subsector to another. I will try to offer some indication of the magnitude of the explosion in information activities and show that this is by no means a postwar phenomenon—that it appears to go back well into the nineteenth century.

Information provision is itself a service or, rather, a bundle of services. Thus, the information sector contributes to the volume of services, while the service sector is the central source of information. This two-way relationship constitutes the basis for a feedback model that raises disturbing possibilities of oscillatory behavior and of dampened productivity growth. My central focus is this two-way interaction and its implications for future economic activity.

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. Computers constantly communicate with one another by telephone, as is widely recognized. It is not generally recognized that in the last few years computation and telecommunications have virtually effected a merger. However, 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 that 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 minicomputers 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.

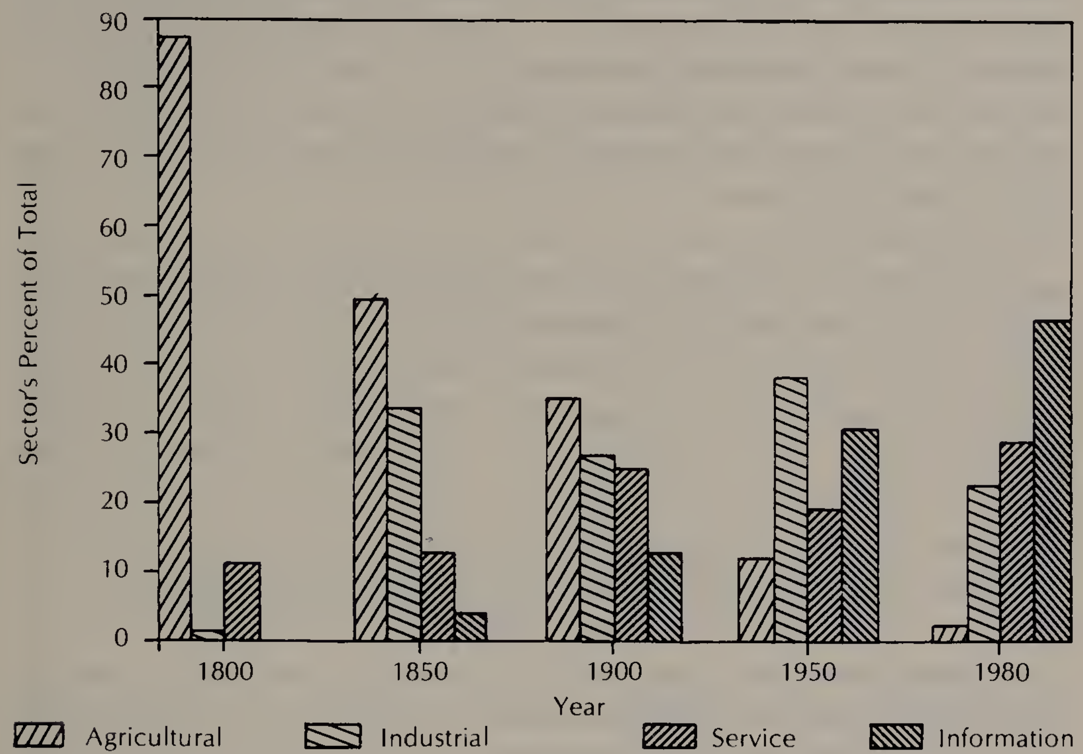
At the other extreme, handicraft services such as live theater, teaching of the humanities, and trash collection have all benefitted from computers that are used for word processing, record keeping, and research. The effects, however, are largely peripheral, and the production process underlying these services goes on fundamentally as it always has. For these services, the cost savings promised by computers have been negligible. This is a contributing factor to their persistently low rate of growth in labor productivity. As we can see, it is very dangerous to lump all services together for analytic purposes for their diversity would prove a likely source of major error.

ON THE GROWTH OF INFORMATION AND OTHER SERVICE ACTIVITIES

Estimates extending well over a century that indicate the course of information and other U.S. service activities relative to manufacturing and agriculture may provide a foundation for our discussion. 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, these figures, taken from work by Professor J. Beniger, provide a reasonably defensible representation of the facts.

Figure 8–1 shows for the period 1800–1980 the share of the U.S. labor force employed in the various sectors. We see that the transition

Figure 8–1. Shares of Labor Force by Sector, 1800–1980.



Source: Beniger (1984).

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 at a bit less than 30 percent of the total. Information, however, starting virtually from zero, occupied more than 45 percent of the U.S. labor force by 1980! Clearly the growing urgency of Veblen's "interstitial adjustments" has had its effects.

However, when 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. The ratio of number of students graduated, orchestral performances attended, number of tons of solid waste removed, and so forth, to number of watches, shoes, and shovels 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 (Maddison 1982) meaning that the industrial output of 1870 could 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.

Similar questions arise about the rate of growth of information outputs, but for more subtle reasons. Many information activities contain a vital component that is essentially handicraft in character—teaching, certain types of research, and 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. 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. This phenomenon has quite appropriately been dubbed the "cost disease" of educational activity.

More surprisingly, there is also evidence 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 seventies 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 (Baumol, Blackman, and Wolff 1985).

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 culate. Potentially, then, much of the 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 a means to preserve the health of the requisite interstitial adjustments.[1]

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 media's productivity—indeed, of their very existence—on the knowledge industry is equally patent. 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. These days our violinist arrives at his work site in a small fraction of the time that it took him 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 is the first half of our feedback relationship. Put rather roughly but not misleadingly, we may say 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 second half of the feedback relationship that is rather more subtle. It 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. Although information activities encourage productivity, if my contention is valid, the latter tends to impede the former. While there is some time lag involved in the process, this description is sufficient to constitute the completed feedback relationship.

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 computer hardware) may be 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.[2] 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—that is, the number of watches that are exchangeable, say, for a subscription to a concert series—would be proportionately 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 or products of laggard activities, in the comparative dynamics sense of the term. 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. This only serves to reduce the share of the overall computation budget accounted for by such products of technology, so a greater proportion of that budget must be devoted to the quasi handicraft portions of computation activity (e.g., software, machine maintenance) 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.

In sum, information activity stimulates productivity growth throughout the economy, but that tends to raise the relative price of computation and other activities. This is almost the end of the story behind the second of our feedback relationships. There is one more step: Products of information activities must be recognized as just another set of inputs into the production process of any firm and, hence, of the economy in general. 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 that 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.

While the explosion of information is likely to continue, the cost disease has the power, in this way, to reduce the rate of growth of information inputs into other activities below what it would have been otherwise.

HOW THE FEEDBACK PROCESS WORKS

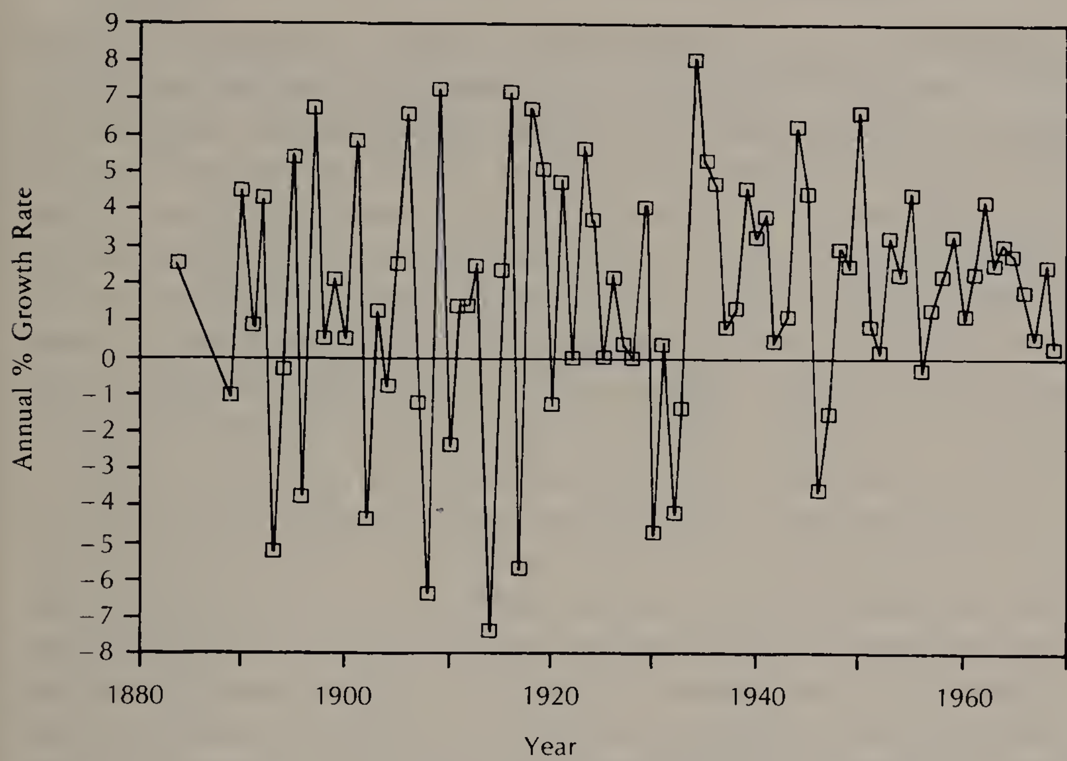
The description of the two basic pieces of the feedback model is now complete. Information flows stimulate productivity growth while productivity growth inhibits the production and dissemination of information. The nature of the feedback loop is clear. It is the mechanism of a sequential process in which today's information flow determines (or at least affects) tomorrow's productivity growth and that in turn affects the next day's 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 is either convergent or explosive. It is easy to demonstrate this formally with the aid of a simple difference equation. It is equally easy to describe the process intuitively. The following would be a typical scenario. 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 handicraft in character. 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 8–2 shows year by year growth rates of total factor productivity in the United States for the better part of a century, calculated from data supplied by Kendrick (U.S. Bureau of Census 1973). (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. Part of the explanation may lie in a process such as the one I have just described, and others like it.

The model has other implications. If the oscillations were really linear, they 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 that is plausible in any event.

Figure 8–2. U.S. Total Factor Productivity Annual Growth, 1884–1969.



Source: U.S. Bureau of Census (1973).

Nonlinearities have a number of implications that I will merely mention. They may produce stable limit cycles that 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. This behavior involves 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, of producing estimates that 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 that 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.

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U.S. Bureau of Census. 1973. *Long-term Economic Growth, 1860*–1970 (June).