The Communications Revolution: America's Third Century Challenge

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Typographical notes

p. 11, two errors: 'Telecommunications' (second bullet point)' presumably should be followed by 'cost'

Also, in the fourth full paragraph, first sentence - 'extricably' presumably should be 'inextricably'

[**Page 1**] In this bicentennial year, we are particularly mindful of our revolutionary origins. The year of 1776 was one of political revolution. Since then the United States has undergone two other revolutions. Both are technological. Both have altered every aspect of our society. The first of these technological revolutions was represented by the conversion of United States society from a pre-industrial to an industrial society. The second is now in full swing and has been characterised by Dr Daniel Bell of Harvard University as the emergence of the world's first post-industrial society.

The American colonies were a pre-industrial society. Before 1800, more than 90% of our population lived on farms. Life was a 'game against nature' as Dr Bell puts it, in which life was a struggle against the vicissitudes of the changing seasons. Power came from nature -- water, human and animal muscle. The strategic resource was raw materials -- food, fiber, lumber and some minerals. Problem-solving was based on tradition, common sense, trial and error, and experience.

By the mid-19th century, the US was well established as an industrial society. Population became concentrated near factories. Cities grew. Life for most became controlled by the production of things. We used created energy -- coal, oil, gas, electricity and more recently, nuclear power -- to add to our power to alter the landscape. Financial capital and labor became the strategic resources of production. Technology, which had been limited to the creation of artisans, switched to machine-generated products and rested on the skills of engineers and skilled and semi-skilled workers. Problem-solving shifted to empiricism and experimentation.

This was also the era of great mechanical inventiveness. Innovations, however, came from the brains of talented thinkers who generally remained ignorant of the discoveries and theories of contemporary scientists. For example, Alexander Graham Bell, our much heralded inventor of the telephone, knew nothing of James Maxwell's work on electromagnetism. Nevertheless, invention piled on top of invention. Technological development snowballed as the nation pursued unlimited economic growth.

Now, however, as we analyze our society, we see that another massive transformation is under way. We are passing from an industrial into a post-industrial society. The strategic resources of a post-industrial society are information and knowledge. By information, I refer to any type of data or facts about anything. Included are data about population, raw materials, manmade products, the environment, and all types of economic, commercial, and governmental transactions. Included are the data required for planning and managing economic and governmental activities and for making numerous personal choices. In addition, there is theoretical knowledge derived from scientific research about the workings of nature. Scientific knowledge about nature forms the basis of major new industries. Scientists, engineers, technicians and professional occupations supply the criticial skills in our post-industrial [**page 2**] society. This trend became particularly evident after World War 1. Before that time, an American scientist with a PhD rarely worked outside the university. Following the war, however, chemical engineering became a widespread profession in the US, and chemistry produced remarkable results for industry.

Chemistry was not the only field of growing scientific and technological progress. Physicists began to open up new areas of progress in electricity and, later, electronics. In 1909, the General Electric Company recruited a promising young physicist, set him up in a laboratory, and permitted him to do basic research. That industrial researcher was Irving Langmuir, later to become a Nobel prize winner. In 1916, the Westinghouse laboratory also hired a PhD who was to become a world-renowned scientist, Arthur H. Compton. Other major industrial companies followed suit, set up laboratories for both applied and basic research, and hired scientists during the period between the two World Wars.

During World War 2 the present and growing values of electronics were forecast by the use of radar and the early computers. This was also the time when the seeds of the space age were sown and the greatest single example of scientific power -- the release of atomic energy -- was demonstrated. Of immense importance, of course, has been the invention of the transistor by Bardeen, Shockley and Brattain, and the development of semiconductors to create the microelectronics industry. More recently, basic research on the possibility of passing a molecular beam through an optical field has led to the creation of a maser and then a laser, which, in turn, gave rise to the hologram. Applications of these discoveries abound, but nowhere are they more evident than in the field of information and data handling. Computers, micrographics, and telecommunications have become driving forces in our information-based society.

Emergence of the post-industrial society does not mean that agricultural and industrial activities have disappeared or have become unimportant. Quite the contrary. Because agriculture has become so efficient, largely due to science and technology, only 4% of our population now produce a substantial amount of our food, plus that needed by a large part of the rest of the world. Like agriculture, industry depends on scientific knowledge for its new growth. At the same time, industrial and commercial transactions increasingly depend on information and data processing. Examples include automated factories; reservation services for airlines and hotels; nationwide inventory control and sales records; and national and international news, entertainment and communication services. These and many other industrial- and service-based jobs are information processing jobs, regardless of the goods or services involved. In addition, many other occupations, including research, development, teaching and various other professional jobs, can be described as information generating, processing or using activities. Collectively, they constitute the information industry. Just as agriculture is the base of the pre-industrial society. and [**page 3**] fabrication work is dominant in an industrial society, information or knowledge occupations characterise the post-industrial society.

This conception may be difficult to grasp. We are attuned to physical representation of industrial society, such as factories and transportation systems. In its early stages, the information industry was also highly visible. It began as the graphic arts industry. While dramatically different from the handwritten manuscripts of previous ages, printed products were still physical items. They were manufactured (printed), shipped and stored just like the things generated by factories. But with advances in printed technology, democratic values, science, and public education, the volume of printed material increased annually. The curve remains ever upward.

Library holdings from several points in time illustrate the long-term information -- if not knowledge -- expansion. Just before the invention of the printing press, a highly educated man’s library, such as Chaucer’s, might contain as many as twenty manuscripts. These he read and studied extensively. The first non-theological library in colonial America, organized in 1731 under the leadership of Benjamin Franklin, initially consisted of 46 titles. Ten years later it had grown to an impressive collection of 375 volumes.

A few years later and a little further south, another library was budding along the Potomac. Its collection of 3000 volumes went up in smoke in 1814 when the British burned parts of Washington. The next year, Thomas Jefferson provided the Library of Congress a second start with the sale of his collection of 6.488 volumes. Since then the growth of the Library of Congress has mirrored the ever-increasing worldwide production of literature. By 1900 the collection numbered 850,000 volumes. At the outset of World War 2, the collection stood at almost 6.4 million volumes. And today it exceeds 70 million pieces of information.

Numerical increase is only one dimension of the “information explosion”. Diversity of form is another. Library holdings illustrate this point as well. Today the Library of Congress -- and other major libraries -- contain books, journals, newspapers, technical reports, manuscripts, maps, microfiche and microfilm, motion pictures, video tapes, recordings, photographs, prints, posters, and computer tapes, disks and other forms of electronic storage.

Growth in the scientific and the technological literature represents another indicator of the increase in the information base of our society. The first scientific journals, one French and the other British, go back to the mid-seventeenth century. Since then, the scientific literature has been doubling about every 10 to 15 years. As shown in figure 1, over 100,000 journals have been published somewhere, some time: today, there are approximately 50,000 current titles in some sixty languages. About 2 million new articles or items are added annually to [**page 5** [*page 4 is figure 1*]] the worldwide scientific and technological literature, With such a growth, it is not surprising that new literature searching tools should develop as well. The first of these abstract journals began in the early 1800s: now there are over two thousand scientific and technical abstracting/indexing publications.

WORLDWIDE GROWTH OF SCIENTIFIC AND ABSTRACT JOURNALS

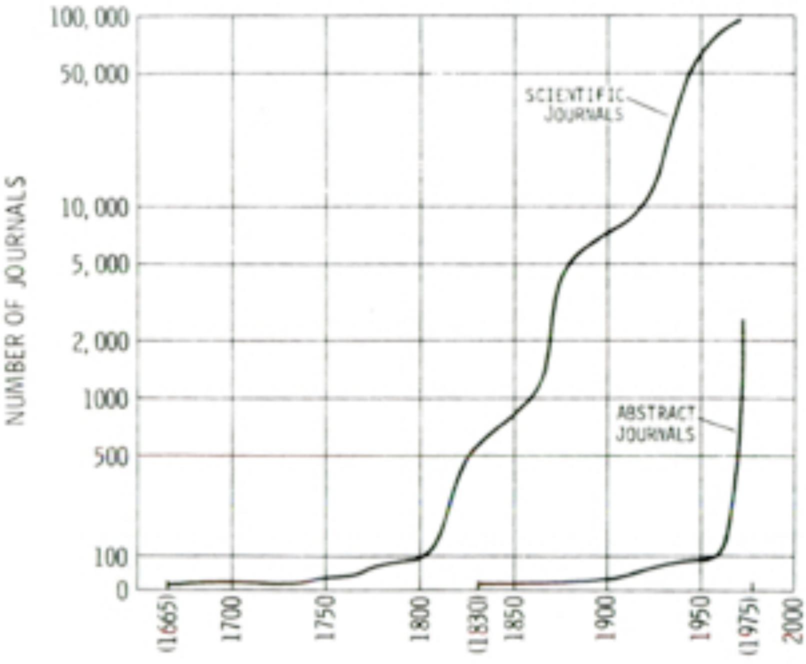

Figure 1

During this period of tremendous growth in scientific and technological (S&T) publication, there was relatively little change in the methods used. All were printed publications. But, beginning just about ten years ago, a remarkable change began with computerization. Today over 200 abstract journals -- or their modern equivalent -- are available in machine-readable form. The history of one commercial firm illustrates growth of computer searching of S&T databases. This firm first offered nationwide searching from computer terminals (called online searching) in 1965. It began with one data base. By 1973, eleven separate files were offered; today, over forty databases can be searched. The number of records available for online searching continues to rise. Again, the experience of this firm is illustrative: from 200,000 in 1965 to 2.1 million in 1973 to 8 million in 1975. Meanwhile, contrary to about everything else in our economy, costs are plummeting. Using an index of 100 for 1970 costs for online searching, 1973 costs had dropped to 40, and 1975 costs to 20. As we will see later, further decreases can be confidently expected.

Conversion of printed abstract journals to electronic form also illustrates the invisible nature of the information industry. Electronic means for recording, distributing and presenting literature and data will dominate the scene in the late 1980s. In contrast to use of printed journals and reports, we will rely more heavily upon display at a terminal of information called from remote locations. Clues to publication will be magnetic tapes from word-processing machines and other forms of electronic storage.

The nonvisible nature of the information industry adds to the difficulty of understanding its significance. The man on the street is visually aware of the industrial base of society. It is all around us. It is represented by factories, transportation facilities and products. The information society equivalent to bulk transportation systems are electronic communication systems. These include voice and data communications links, whether by wires, microwave or satellite linkages.

But the transformation remains unseen. Likewise, the occupational shift to information-related jobs has been unnoticed in society at large. Yet large and significant shifts have occurred. There are two ways of documenting the trend toward the dominance of the information industry in our society. One consists of examining trends in the portion of the Gross National Product (GNP) attributable to different economic sectors. The other focuses on the percentage of the labor force in various major occupational groupings.

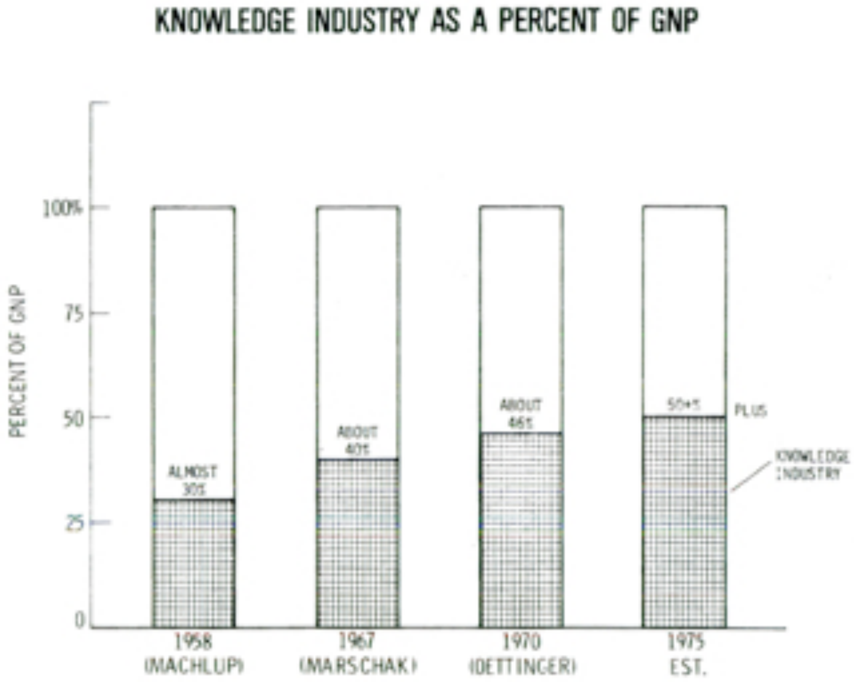

Figure 2

Let us look first at the GNP data. Several analysts have tried to estimate what proportion of the GNP is accounted for by activities concerned with generating, processing, disseminating and using information and knowledge (figure 2). The first estimate was made in 1958 by Professor Machlup in his book, *The Production and Distribution of Knowledge*. He put the figure at nearly 30%. In 1967, Professor Marschak reworked available data and raised the estimate to almost 40%. Three years later, Dr Oettinger further upped the figure to 46%. Today, experts believe that over half the GNP is contributed by the information industry.

Analysis of labor force data leads to the same conclusion. Here we are indebted to analyses developed by Marc Porat and Dr Edward Parker from Stanford University. Their definition of information occupations include those jobs in which:

* Information is a final product. This includes the newspaper and printing industry; broadcasting and motion picture; telephone and telegraph; libraries and postal service.
* Information is a major intermediate product. Included here are financial institutions; real estate; legal; advertising; education; engineering and architecture; accounting and auditing; government administration and commercial research and development (R&D).
* Information industry. Occupational fields in this case include computer and communications; scientific instruments; and office, computing and accounting equipment manufecture, sales and service.

Remaining occupations are classified as being in non-information industries.

Using these definitions, the Stanford researchers traced trends in US information and non-information fields since 1860 (figure 3). Information occupations started at about 5% of the work force in 1860 and remained approximately 10-15% until 1950. Immediately following World War 2, occupations in the information sector exploded in size and grew rapidly. During the present decade (1970-1980), the information occupations emerged as the largest group in the work force. It is unlikely that this trend will reverse.

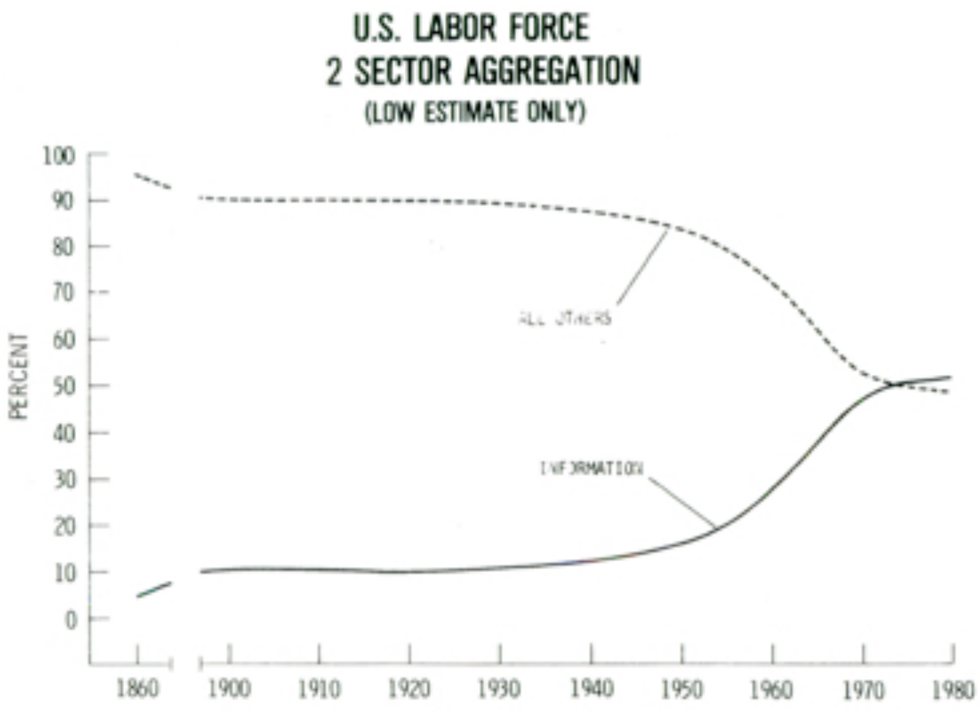

Figure 3

Porat and Parker undertook a more detailed analysis. They divided the work force into four major independent categories: agriculture, industry, services and information. Independence was achieved by separating information jobs in agribusiness, such as researchers, sales persons, accountants, secretaries, and other information jobs from other agricultural jobs. The industry classification [**page 9** [*page 8 is figure 3*]] included blue-collar plus all jobs not classified elsewhere. Service cluster includes domestic, repairmen and public service workers engaged in non-information work (policemen, firemen, or sanitation workers). While more illuminating, the results are the same as before.

But, with these distinctions, we can identify several separate trends (figure 4). Prior to 1860, the largest labor group in the US was the agricultural, comprising 36% of the work force. By 1900, industry had begun to take over, absorbing workers from the countryside into the urban factories. At this time, 20% of the work force was in services, largely personal and domestic, while information workers amounted to only 10% of the labor force. As the agricultural sector contracted and receded to its present 4% of the work force, the industrial sector grew rapidly. Between 1935 and 1955, the US was predominantly an industrial society, peaking in 1950 with about 65% of the work force.

Figure 4

Around 1945, we had almost equal proportions of agriculture, services and information workers, each around 12% of the work force. Services and agriculture had been receding slowly, and information had been increasing. After this period, however, the information sector grew very quickly in proportion, not by pulling people away from the industry sector (whose membership in absolute terms grew somewhat) but by capturing most of the new entrants into the labor pool. In the late 1960s the information sector surpassed a quickly dwindling industrial sector, and is now by far the largest single group. These curves closely mirror Daniel Bell's thesis that the United States has progressed through three stages -- from agriculture to industrial to post-industrial; and that we are now firmly embarked on the third era.

Trends towards an information-based economy are well established. A number of driving forces stand behind these trends. One is the search for more efficient and cost-effective ways of producing goods and services. Applied research and development expenditures are an indication of this force. Another is expenditures in basic research in order not to deplete the stock of theoretical knowledge. Further, R&D expenditures have shifted to the communications field. In recent years, aerospace dominated United States R&D. In 1973, R&D on electronics and telecommunications took over the lead. From this research will come future information-processing and telecommunications technologies, industries, systems and jobs.

Another driving force is the cost-effective attractiveness of electronic-based operations. To illustrate:

* Computer costs are declining exponentially, while cost/performance is increasing similarly. This includes costs and performance for mainframes, mini-computers, micro-processors, and related storage devices.
* [**page 11** [*page 10 is figure 4*]] Costs for terminals are also declining while performance is constantly improving.
* Telecommunications, which have remained high relative to computing operations, are now declining and will drop drastically in the future. [*see editorial note on first page*]

In contrast, conventional communication, based on the printed word and postal services, will continue to increase in cost.

Further impetus for accelerated development and use of communication technologies comes from our desires to conserve energy. In contrast to moving people, which represents high-energy consumption, communications based on audio or video transmission or computer conferencing can allow communications and decision-making, without the costs of transportation and high energy consumption.

The net result will be to accelerate communication via electronic networks. As a result, more jobs and personal experience -- banking, purchasing, and communications with friends and work associates -- will be based on use of terminals.

Thus, the electronic media and the post-industrial society are extricably intertwined [*see editorial note on first page*]. Universities have recognized this fact. Engineering, science, business administration and other curricula include instruction in computer operations. Computer, library, and information science instruction is in healthy ferment. Individuals initially educated in one of these fields move easily to the other and, further, to a wide range of jobs in the public and private sectors. As welcome and important as these changes are, two further and even more significant improvements, I believe, are necessary if we are to reap the full benefits of the coming communications revolution.

First, we should set about systematically to create "information literacy" for all adults in the nation, so each can function effectively in our emerging society. Second, we should begin preparing individuals who will be able to comprehend and apply our new communication capabilities creatively across the spectrum of society's needs so that we fully benefit from the potential of our new technologies.

Information literacy goes beyond conventional literacy -- the ability to read and write in acceptable, or at least passable, English. Regardless of how successful we have been with conventional literacy, we need to look ahead to achieving a new kind of national literacy -- information literacy. To be information literate requires a new set of skills. These include how to efficiently and effectively locate and use information needed for problem-solving and decision-making. Such skills have wide applicability for occupational as well as personal activities. Part of such competency includes comfortable use of a computer terminal for sifting through available information from various data banks to select useful data for resolving the problem at hand.

[**page 12**] No college graduate today should be without such skills. Consider our 1977 graduates. By the year 2000 they will be in their mid-careers. By then, many will have substantial management responsibilities. Management roles will be greatly influenced, if not dominated, by automated communications. Even by 1990, only thirteen years out, all indicators point to substantially electronic means of distributing information. Freshmen entering the labor market in less than ten years face similar prospects. Job performance, including management competence, will depend upon information literacy as well as competency in one's chosen field.

Also, if our present forecasts are correct, computer-terminal devices will be common in the home within a decade. From such devices we will do our banking, shopping, plan vacations, and communicate with friends. We will have our choice of voice, digital, graphic or pictorial forms of presentation. All family members will use such devices, just as pre-school children today master the telephone, record and tape players, and television sets.

As these technologies become more common, elementary schools will take over the responsibility for creating information literate citizens. Universities, however, can ill afford to wait. Also university experience as in so many fields, can become the basis for subsequent school programs.

Second, we need to give attention to preparing individuals who can anticipate and develop appropriate data teleprocessing and related telecommunications systems for whatever needs to be done -- in managing economic activities or providing educational and community services. The only real limit to the development of the automated systems is the shortage of people who can comprehend them, develop them, change them, and anticipate the consequences of their operations. As such systems become more sophisticated, people with the necessary perspective and understanding become scarcer. We may be deceived by the ease with which we can train technicians to do specialized tasks required by computers and information processing networks. What is critically needed are people who understand these new systems and how they can be applied to economic, health, educational, and community requirements. Individuals with these skills command a premium in the emerging post-industrial society. Universities with foresight and resolve can be in the vanguard in meeting the nation's future needs in this critical area.

As we enter our third century, the post-industrial society and its information and communication base present numerous challenges. I am confident we will apply these new resources for the benefit of all our citizens. The communications area allows us to focus three of our outstanding and unique capabilities. These are our confidence in ourselves and our optimism about what we can accomplish; our ability to sustain technological innovation; and our management expertise.

Here is a challenge fitting for our third century….