# The Transformation of Work in the New Economy

## *Sociological Readings*

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# 10 Technology: The 'Great Growling Engine of Change'

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Without recent advances in computer-based production systems and telecommunications technology, we could not have created the *new economy*, which is the subject of this book. In this chapter, Peter Dicken invites the reader to see technology as the engine of change and discusses technology in terms of four broad change-related types: small-scale incremental innovation; radical innovations that affect specific products or processes; far-reaching changes in technology that give rise to new economic sectors, like biotechnology; and large-scale revolutionary changes, such as the computer, that transform products and styles of production and management that affect almost every branch of the economy.

Dicken identifies the main features of technological change that have been responsible for the globalization of economic activity. He also cautions readers not to adopt a "deterministic" view of technology that assumes that new technology will inevitably be adopted and produce a particular outcome. A nondeterministic view of technology says that the choice of whether to use a new technology is usually a political choice based on a struggle between those who believe they will benefit and those who believe they will be harmed.

## Technology and Economic Transformation

Technological change is at the heart of the process of economic growth and economic development. As Joseph Schumpeter (1943, p. 83) pointed out many years ago, 'the fundamental impulse that sets and keeps the capitalist engine in motion comes from the new consumers' goods, the new methods of production or transportation, the new markets, the new forces of industrial organization that capitalist enterprise creates'. Technological change is the 'prime motor of capitalism'; the 'great growling engine of change' (Toffler, 1971); the 'fundamental force in shaping the patterns of transformation of the economy' (Freeman, 1988); the 'chronic disturber of comparative advantage' (Chesnais, 1986). Although technologies, in the form of inventions and innovations, originate in specific places, they are no longer confined to such places. Innovations spread or diffuse with great rapidity under current conditions. Indeed, one of the most significant sets of innovations is in the sphere of communications, which itself facilitates such technological diffusion. As we shall see, however, this does not signal the 'death of distance' or 'the end of geography'. Indeed, there continues to be a pronounced geography of knowledge creation and a strong geographical localization of innovative activity.

Technology is, without doubt, one of the most important contributory factors underlying the internationalization and globalization of economic activity:

> Technological change, through its impact on the economics of production and on the flow of information, is a principal factor determining the structure of industry on a national scale. This has now become true on a global scale.

> Long-term technological trends and recent advances are reconfiguring the location, ownership, and management of various types of productive activity among countries and regions. The increasing ease with which technical and market knowledge, capital, physical artefacts, and managerial control can be extended around the globe has made possible the integration of economic activity in many widely separated locations. In doing so, technological advance has facilitated the rapid growth of the multinational corporation with subsidiaries in many countries but business strategies determined by headquarters in a single nation. (Brooks and Guile, 1987, p. 2)

However, in looking specifically at technology in this chapter, we need to beware of adopting a position of technological determinism. It is all too easy to be seduced by the notion that technology 'causes' a specific set of changes, makes particular structures and arrangements 'inevitable' or that the path of technological change is linear and sequential. Technology in, and of, itself does not cause particular kinds of change. In one sense, then, technology is an enabling or facilitating agent: it makes possible new structures, new organizational and geographical arrangements of economic activities, new products and new processes, while not making particular outcomes inevitable. But in certain circumstances technology may, indeed, be more of an imperative. In a highly competitive environment, once a particular technology is in use by one firm, then its adoption by others may become virtually essential to ensure competitive survival. More generally, as Freeman (1982, p. 169) points out, for business firms 'not to innovate is to die'.

In this chapter we focus only on certain aspects of technology and technological change: those which specifically influence the processes of internationalization and globalization of economic activity. The chapter is divided into four major parts:

- First, some of the broad characteristics of technological change are discussed in order to identify the key technologies and their evolution over time.
- Second, we focus on the 'space shrinking' technologies of transport and communication which are obviously central to the processes of internationalization and globalization.
- Third, we look at technological changes in both products and processes and explore the extent to which totally new forms of production technology and organization are occurring.
- Fourth, we focus explicitly on the geography of innovation, in particular on the tendency of innovative activity and knowledge creation to be geographically localized in 'technology districts'.

## The Process of Technological Change: An Evolutionary Perspective[1]

Technological change is a form of learning: of how to solve specific problems in a highly diverse, and often volatile, environment. It is, however, more than a narrowly 'technical' process. Technology is also not independent or autonomous; it does not have a life of its own. Technology is a social process which is socially and institutionally embedded. It is created and adopted (or not) by human agency: individuals, organizations, societies. The ways in which technologies are used—even their very creation—are conditioned by their social and their economic context. In effect, from the viewpoint taken here, this means the values and motivations of capitalist business enterprises operating within an intensely competitive system. Choices and uses of technologies, therefore, are influenced by the drive for profit, capital accumulation and investment, increased market share and so on.

## A Typology of Technological Change

Freeman and Perez (1988) identify four broad types of technological change, each of which is progressively more significant:

- *Incremental innovations:* the small-scale, progressive modification of existing products and processes:

  > They may often occur, not so much as the result of any deliberate research and development activity, but as the outcome of inventions and improvements suggested by engineers and others directly engaged in the production process, or as a result of initiatives and proposals by users ('learning by doing' and 'learning by using'). . . . Although their combined effect is extremely important in the growth of productivity, no single incremental innovation has dramatic effects, and they may sometimes pass unnoticed and unrecorded. (Freeman and Perez, 1988, p. 46)

- *Radical innovations:* discontinuous events which may drastically change existing products or processes. A single radical innovation will not, however, have a widespread effect on the economic system; 'its economic impact remains relatively small and localized unless a whole cluster of radical innovations are linked together in the rise of new industries and services, such as the synthetic materials industry or the semiconductor industry' (Freeman, 1987, p. 129).

- *Changes of 'technology system':* 'these are far-reaching changes in technology, affecting several branches of the economy, as well as giving rise to entirely new sectors. They are based on a combination of radical and incremental innovations, together with organizational and managerial innovations affecting more than one or a few firms' (Freeman and Perez, 1988, p. 46). Freeman (1987) suggests that the following five 'generic' technologies have created such new technology systems:

  1) information technology.

  2) biotechnology.

  3) materials technology.

  4) energy technology.

  5) space technology.

- *Changes in the techno-economic' paradigm:* the truly large-scale revolutionary changes which are

  > the 'creative gales of destruction' that are at the heart of Schumpeter's long wave theory. They represent those new technology systems which have such pervasive effects on the economy as a whole that they change the 'style' of production and management throughout the system. The introduction of electric power or steam power or the electronic computer are examples of such deep-going transformations. A change of this kind carries with it many clusters of radical and incremental innovations, and may eventually embody several new technology systems. Not only does this fourth type of technological change lead to the emergence of a new range of products, services, systems and industries in its own right—it also affects directly or indirectly almost every other branch of the economy . . . the changes involved go beyond specific product or process technologies and affect the input cost structure and conditions of production and distribution throughout the system. (Freeman, 1987, p. 130)

## Information Technology: A Key Generic Technology[2]

. . . The first of the five 'generic' technologies referred to above is information technology (IT). 'The contemporary change of paradigm may be seen as a shift from a technology based primarily on cheap inputs of energy to one predominantly based on cheap inputs of information derived from advances in microelectronic and telecommunications technology' (Freeman, 1988, p. 10). Information technology, there-

fore, is the new techno-economic paradigm around which the next wave of technological and economic changes will cluster. But, as Hall and Preston (1988, p. 30) point out, information technology in itself is nothing new: 'for thousands of years, since the first cave paintings and the invention of writing humans have used tools and techniques to collect, generate and record data'. Consequently, they identify three main phases of information technology:

- Simple pictorial representation and written language, evolving eventually into printing: its basic elements were paper, writing instruments, ink and printing presses.
- Mechanical, electromechanical and early electronic technologies which developed during the late nineteenth and early twentieth centuries: the basic elements were the telephone, typewriter, gramophone/phonograph, camera, tabulating machine, radio and television.
- Microelectronic technologies, which emerged only in the second half of the twentieth century: the basic elements are computers, robots and other information-handling production equipment, and office equipment (including facsimile machines). Hall and Preston regard the first of these as 'old IT'; the second and third together as 'new IT'. They then employ a further term 'convergent IT' to refer to the newest advances of the 1970s and 1980s, whereby computers and telecommunications became integrated into a single system of information processing and exchange.

It is this quality of the convergence of two initially distinct technologies which is of the greatest importance for developments in today's (and tomorrow's) global economy. It is this kind of information technology which is most significant for the processes of internationalization and globalization of economic activities. When we use the term 'information technology' or 'IT' in this and the following chapters it is the convergent IT which is involved. . . .

## The 'Space-Shrinking' Technologies[3]

A fundamental prerequisite of the evolution of international production and of the transnational corporation [TNC] is the development of technologies which overcome the frictions of space and time. The most important of such enabling technologies—and the most obvious—are the technologies of transport and communications. Neither of these technologies can be regarded as the cause of international production or of the TNC; rather, they make such phenomena feasible. But without them, today's complex global economic system simply could not exist. Indeed, both the geographical and organizational scale at which any human activity can occur is directly related to the available media of transport and communication. Similarly, the degree of geographical specialization—the spatial division of labour—is constrained by these media.

Transport and communication technologies perform two distinct, though closely related and complementary roles:

- *Transport systems* are the means by which materials, products and other tangible entities (including people) are transferred from place to place.
- *Communication systems* are the means by which information is transmitted from place to place in the form of ideas, instructions, images and so on.

For most of human history, transport and communications were effectively one and the same. Prior to the invention of electric technology in the nineteenth century, information could move only at the same speed, and over the same distance, as the prevailing transport system would allow. Electric technology broke that link, making it increasingly necessary to treat transport and communication as separate, though intimately related, technologies. Developments in both have transformed our world, permitting unprecedented mobility of materi-

als and products and a globalization of markets.

## Major Developments in Transport Technology

In terms of the time it takes to get from one part of the world to another there is no doubt that the world has 'shrunk' dramatically. . . . For most of human history, the speed and efficiency of transport were staggeringly low and the costs of overcoming the friction of distance prohibitively high. Movement over land was especially slow and difficult before the development of the railways. Indeed, even as late as the early nineteenth century, the means of transport were not really very different from those prevailing in biblical times. The major breakthrough came with two closely associated innovations: the application of steam power as a means of propulsion and the use of iron and steel for trains and railway tracks and for oceangoing vessels. These, coupled with the linking together of overland and ocean transport and the cutting of the canals at Suez and Panama, greatly telescoped geographical distance at a global scale. The railway and the steamship introduced a new, and much enlarged, scale of human activity. The flow of materials and products was enormously enhanced and the possibilities of geographical specialization were greatly stimulated. Such innovations were a major factor in the massive expansion in the global economic system during the nineteenth century.

The twentieth century, and especially the past few decades, has seen an acceleration of this process of global shrinkage. In economic terms, the most important developments have been the introduction of commercial jet aircraft, the development of much larger ocean-going vessels (superfreighters) and the introduction of containerization, which greatly simplifies transhipment from one mode of transport to another and increases the security of shipments. Of these, it is the jet aircraft which has had the most pervasive influence, particularly in the development of the TNC. It is no coincidence that the take-off of TNC growth and the (more literal) take-off of commercial jets both occurred during the 1950s. As a consequence in terms of time, New York is now closer to Tokyo than it was to Philadelphia in the days of the thirteen colonies. . . .

However, although the world has shrunk in relative terms, we need to be aware that . . . such shrinkage is highly uneven. The technological developments in transport (and in communications) tend to be geographically concentrated. What the geographer Donald Janelle called *time-space convergence* affects some places more than others. While the world's leading national economies and the world's major cities are being pulled closer together others—less industrialized countries or smaller towns and rural areas—are, in effect, being left behind. . . .

## Major Developments in Communications Technology

Both the time and relative cost of transporting materials, products and people have fallen dramatically as the result of technological innovations in the transport media. However, such developments have depended, to a considerable degree, on parallel developments in communications technology. In the nineteenth century, for example, neither rail nor ocean transport could have developed as they did without the innovation of the electric telegraph and, later, the oceanic cable. Only with the ability to transmit information at great speed—for example to co-ordinate flows of commodities on a global scale—could the potential of the transport technologies be fully realized. Similarly, the far more complex global transport system of the present day depends fundamentally on telecommunications technology.

The communications media are, however, fundamentally significant in their own right. Indeed, as implied in our earlier discussion of the central role of information technology, communications technologies should now be regarded as the key technology transforming relationships at the global scale. 'The new telecommunica-

tions technologies are the electronic highways of the informational age, equivalent to the role played by railway systems in the process of industrialization' (Henderson and Castells, 1987, p. 6).

***Transmission channels: Satellites and optical fibres.*** Global communications systems have been transformed radically during the past twenty or thirty years through a whole cluster of significant innovations in information technology. Probably the most important catalyst to enhanced global communications was the development of satellite technology. . . .

Satellite technology, together with a whole host of other communications technologies, is making possible quite remarkable levels of global communication of conventional messages and also the transmission of data. In this respect, the key element is the linking together of computer technologies with information-transmission technologies over vast distances. It has become possible for a message to be transmitted in one location and received in another on the other side of the world virtually simultaneously. Consequently,

> communications costs are becoming increasingly insensitive to distance. The crucial fact is the economics of satellite communication. Within the beam of a satellite it makes no difference to costs whether you are transmitting for five hundred miles or five thousand miles. The message goes from the earth station up twenty-two thousand three hundred miles to the satellite and down again twenty-two thousand three hundred miles. It makes no difference whether the two points on earth are close together or far apart. . . . The important point about satellites is that their existence sets a limit on the extent to which costs are a function of distance. Many other technologies may compete with satellites, but in the end, satellite communication will ultimately be cheaper. Whatever that distance, it makes no difference how much further one communicates, the costs will be the same. Under those circumstances, the cost of access to any particular data base or information service becomes largely independent of its location. That does not make it free nor even necessarily cheap. There are costs for compiling the data and costs for manipulating it. (de Sola Pool, 1981, pp. 162–63)

Satellite communications are now being challenged by a new technology: optical fibre cables. Optical fibre systems have a very large carrying capacity, and transmit information at very high speed and with a high signal strength. 'Each hair-like strand can now accommodate up to 60,000 simultaneous telephone calls (as opposed to 6–7,000 for a much wider coaxial cable)' (Graham and Marvin, 1996, p. 18). . . .

Nevertheless, only the very large organization, whether business or government, yet has the resources to utilize fully the new communications technologies. For the TNC, however, they have become essential to its operations.[4] All TNCs operate immense international telecommunications networks. They are the major users of international leased telecommunications networks, which permit them to transmit their internal communications at great speed to other parts of their international corporate network. . . . It is the possession of such instantaneous global communication systems that enables the TNC to operate globally, whether it is engaged in manufacturing, resource exploitation or business services. . . .

## Summary

Technological developments in communications media have transformed space-time relationships between all parts of the world. Of course, not all places are equally affected. Consistent with the nature of the time-space convergence process, as defined by Janelle, is its inherent geographical unevenness. In general, the places which benefit most from innovations in the communications media are the 'important' places. New investments in communications technology are market related; they go to where the returns are likely to be high. The cumulative effect is to reinforce both certain communications routes at the global scale

and to enhance the significance of the nodes (cities/countries) on those routes. For example, although developing countries contain around 75 per cent of the world's population they have only around 12 per cent of the world's telephone lines. 'A new geography of rich and poor is emerging with the poor now those deprived of access to . . . communications technology' (Batty and Barr, 1994, p. 711). There is an additional factor which limits the universal spread of new communications technologies. In virtually all countries of the world, governments regulate the communications industries within their borders. Today, however, there is a strong trend towards the deregulation of telecommunications in several countries. Within this geographically uneven communications surface there is also a social dimension. Not everybody—whether they are business firms or private individuals—has equal access. Despite the general decline in communications costs driven by technological change, the costs of usage are far from trivial.

Nevertheless, although we need to beware of the hype which surrounds the 'information revolution', there is no doubt that epochal changes are occurring through the development of digital technologies:

> The rapid advance of digital systems, based on the 'ones and zeros' of binary computer language, is sweeping away the remaining differences between data processing and telephony, and leading to the dawn of a new information age, epitomized by the explosive growth of the Internet and internal corporate intranets. . . . Digital technology has made it possible to convert text, sound, graphics and moving images into coded digital messages which can be combined, stored, manipulated and transmitted quickly, efficiently, and in large volumes over wired and wireless networks without loss of quality. As a result, electronic commerce and the multimedia revolution are driving the computing and telecommunications worlds into ever-closer competition and cooperation. 'The coming era of digital personal communications is an era of converging technologies, converging products, converging media and converging industries.' (*The Financial Times*, 5 March 1997)

## Technological Changes in Products and Processes

When thinking of 'products' most of us tend to think of consumer products. But, for industry as a whole, most products are themselves intermediate in nature; they form the inputs to subsequent stages in the production chain. Bearing in mind this intricate relationship between product and process, however, it is useful to look at them separately in the first instance. . . .

### The Production Process and Technology

In today's intensely competitive global environment product innovation alone is inadequate as a basis for a firm's survival and profitability. Firms must endeavour to operate the production process as efficiently as possible. Recent developments in technology—and, especially, in information technology—are having profound effects upon production processes in all economic sectors. Three major, and closely interrelated, decisions are involved in the production process (Smith, 1981):

- The *technique* to be adopted. This decision concerns both the particular technology used and also the way in which the various inputs or factors of production are combined. It is almost always possible to vary the precise combination of, say, labour and capital according to their relative availability and cost. However, there are limits to such substitution of factors. Some production processes are intrinsically more capital intensive than others and *vice versa*. Closely related to the question of technique is that of
- The *scale of production*. In general, the average cost of production tends to de-

cline as the volume of production increases. The extent of such economies of scale varies considerably from one industry to another. They are much greater, for example, in automobile production than in the manufacture of fashion garments. Technique and scale are, themselves, closely related. . . .

- *Location.* The choice of location cannot be considered in isolation from scale and technique. Different scales of operation may require different locations to give access to markets of different sizes. . . . Different techniques will favour different locations, as firms tend to gravitate toward cheap sources of the inputs required in the largest quantities, and location itself can influence the combination of inputs and hence the technique adopted. (Smith, 1981, pp. 23–24)

Clearly, therefore, a firm which is seeking to reduce its production costs or to increase its efficiency and productivity can seek such economies at different points in the production process. It can attempt to purchase lower-cost inputs. In the case of material inputs this increasingly involves a shift to supplies in developing countries. In the case of labour, a relatively immobile factor of production, the search for lower costs may involve the physical relocation of production to a cheap labour location.

## Flexibility: The World 'After Fordism'

This point leads us to consider the major recent developments that have been occurring in the technology of production processes and, particularly, those associated with the new techno-economic paradigm of information technology. Most technological developments in production processes are, as we observed earlier, gradual and incremental: the result of 'learning by doing' and of 'learning by using'. But periods of radical transformation of the production process have occurred throughout history. We are now in the midst of such a radical transformation.

Over the long timescale of the development of industrialization, the production process has developed through a series of stages each of which represents increasing efforts to mechanize and to control more closely the nature and speed of work. The stages generally identified are:

- *Manufacture:* the collecting together of labour into workshops and the division of the labour process into specific tasks.
- *Machinofacture:* the application of mechanical processes and power through machinery in factories. Further division of labour.
- *Scientific management* ('Taylorism'): the subjection of the work process to scientific study in the late nineteenth century. This enhanced the fineness of the division of labour into specific tasks together with increased control and supervision.
- *'Fordism':* the development of assembly-line processes which controlled the pace of production and permitted the production of large volumes of standardized products.
- *'After-Fordism':* the development of new flexible production systems based upon the deep application of information technologies. . . .

The Fordist system was characterized by very large-scale production units using assembly-line manufacturing techniques and producing large volumes of standardized products for mass market consumption. It was a type of production especially characteristic of particular industrial sectors, notably automobiles. Not all sectors, nor all production processes, lent themselves to such a system of mass production but it was seen to be the main characteristic. . . . Many now argue that this Fordist system of production (and its associated organizational structures) entered a period of 'crisis' from about the mid-1970s and that it has been replaced by new modes of production.

The most important characteristic of this new system is claimed to be flexibility: of the production process itself, of its organization within the factory and of the organization of relationships between customer and supplier firms.

The key to production flexibility lies in the use of *information technologies* in machines and operations. These permit more sophisticated control over the production process. With the increasing sophistication of automated processes and, especially, the new flexibility of electronically controlled technology, far-reaching changes in the process of production need not necessarily be associated with increased scale of production. Indeed, one of the major results of the new electronic and computer-aided production technology is that it permits rapid switching from one part of a process to another and allows the tailoring of production to the requirements of individual customers. "Traditional" automation is geared to high-volume standardized production; the newer 'flexible manufacturing systems' are quite different:

> Flexible automation's greatest potential for radical change lies in its capacity to manufacture goods cheaply in small volumes. . . . In the past batch manufacturing required machines dedicated to a single task. These machines had to be either rebuilt or replaced at the time of product change. Flexible manufacturing brings a degree of diversity to manufacturing never before available. Different products can be made on the same line at will. . . . The strategic implications for the manufacturer are truly staggering. Under hard automation the greatest economies were realised only at the most massive scales. But flexible automation makes similar economies available at a wide range of scales. A flexible automation system can turn out a small batch or even a single copy of a product as efficiently as a production line designed to turn out a million identical items. (Bylinsky, 1983, pp. 53–54)

What does this all mean in terms of the broader question of what comes 'after-Fordism'? There are strongly opposed interpretations of the nature of Fordism itself (for example, the extent to which it really constituted an all-embracing system of production, even in its heyday) and of what it is being replaced by.[5] Is it a variant on Fordism, 'neo-Fordism', in which automated control systems are applied within a Fordist structure? Or is it a totally new 'post-Fordism', in which the new technologies create quite different forms of production organization? It is a debate which stretches way beyond the bounds of technology and technological change into the realms of the social organization of production, of the ways in which the state regulates economic activity, and the nature of consumption and markets. . . .

***Flexible specialization: The rebirth of craft-based production?*** Some assert unequivocally that flexible specialization is becoming the norm; the dominant style of production displacing Fordism. This is the 'post-Fordist' view which sees the hegemony of Fordism as being replaced by a new regime of flexible production and smaller organizational units. It is the viewpoint most closely associated with the work of Piore and Sabel whose 1984 book, *The Second Industrial Divide,* triggered off much of the 'after-Fordist' debate. As we have seen, Fordism was associated overwhelmingly with very large, vertically integrated firms producing standardized goods at very large volumes to benefit from economies of scale in production and selling to mass consumer markets. Piore and Sabel's interpretation of the development of flexible production technologies is that it leads to the resurgence of small, independent entrepreneurial firms emancipated from the tyrannies of mass production by the new flexibility which permits small-scale operations to serve small (perhaps local) markets. . . .

This craft-based, 'flex-spec' interpretation of the changes in the production system also sees it as heralding a process of reskilling of labour as opposed to the relatively low skills characteristic of Fordism. The deintegration of the production system

also goes hand-in-hand with a deintegrated organizational structure which then develops as horizontal networks of inter-related, specialist firms. . . .

## Conclusion

The aim of this chapter has been to identify some of those features of technological change which are most important in the internationalization and globalization of economic activity. Technological change is at the dynamic heart of economic growth and development; it is fundamental to the evolution of a global economic system. We focused on four specific aspects of technological change.

First, we explored the process of technological change as an evolutionary process in which much change is gradual and incremental, often unnoticed but none the less extremely significant. But there are periodic radical transformations of existing technologies—revolutionary developments in clusters of technologies—which dramatically alter not only products and processes in one industry but which also pervade the entire socioeconomic system. These are the shifts in the technoeconomic paradigm which seem to be associated with the long waves of economic change.

Second, we concentrated on what is undoubtedly the major technological driving force today: the convergence of two initially distinct technologies—computer technology and communications technology—into a single, though complex, strand: information technology. IT is transforming both the technologies of transport and communication and also the technologies of products and processes. IT is capable of spreading into all sectors of the economy and to all types and sizes of organization but it is still the very large business organization, particularly the TNC, which is reaping the greatest benefits.

Third, we argued that the claim that we are shifting from one hegemonic (Fordist) system to another hegemonic (post-Fordist) system is far too sweeping and simplistic to capture the complex reality of a world based upon increased flexibility of production and organization. There are a number of alternatives to Fordism which, although they are all based upon the new flexibilities, take on rather different forms. We need to recognize the existence of such diversity. Part of that diversity is related to the fourth focus of the chapter: the strongly localized nature of innovation and technological change. The path-dependent nature of technological change and the social conditions within which such change occurs give major importance to the *geography* of the process.

In concluding this chapter, then, we should again remind ourselves that technological change, in itself, is not deterministic. We must not assume that a particular technology will lead inevitably and irrevocably to a particular outcome. More realistically

> A frontier of new possibilities has been defined: a frontier which identifies the types of new products and services that can be made available. That frontier is itself a product of past choices. . . . Specific choices within the frontier of technological possibilities are not the product of technological change; they are, rather, the product of those who make the choices within the frontier of possibilities. *Technology does not drive choice; choice drives technology.* (Borrus, quoted in Cohen and Zysman, 1987, p. 183, emphasis added)

## Discussion Questions

1. What might have been some of the political forces that favored development of the auto industry over development of a mass transportation system?
2. Can you think of a technology that has potential value but has not been developed and adopted?
3. What past technological innovation has had the greatest impact on American

society? The internal combustion engine? The telephone? Air travel?



## Endnotes

1. This kind of perspective on technological change is based upon the work of Perez (1985), Freeman (1982; 1987), Dosi et al. (1988). See also Metcalfe and Diliso (1996).
2. Useful general introductions to information technology can be found in Forester (1985; 1987). More advanced treatments are provided by Freeman (1987), Hall and Preston (1988), Hepworth (1989), Castells (1996).
3. For broad-ranging discussions of these technologies, see Hall and Preston (1988), Brunn and Leinbach (1991), Castells (1996), Graham and Marvin (1996).
4. These data are from Baylin (1996).
5. There is a huge literature on this subject. Important contributions are provided by Piore and Sabel (1984), Blackburn, Coombs and Green (1985), Gertler (1988), Coombs and Jones (1989), Kenney and Florida (1989), Schoenberger (1988a, 1989), Sayer and Walker (1992), Amin (1994), Ruigrok and van Tulder (1995).

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